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TRANSMISSION OF NUCLEAR POLYHEDROSIS VIRUS OF RICE SWARMING CATERPILLAR *SPODOPTERA MAURITIA* (BOISDUVAL) THROUGH EGG

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(Received 26 February 1984)

Experiments were conducted to study the mechanism of transmission of the nuclear polyhedrosis virus of *Spodoptera mauritia* through egg. The results showed that transmission of the virus from parent to progeny was mainly through surface contamination of eggs (transovum). However the low larval mortality observed even after the egg was surface sterilized or when surface sterilized egg homogenate was fed to the larva, indicated the possibility of virus transmission through transovarial route also. Both virus fed moths and virus contaminated moths could transmit the virus to their progeny through surface contamination of egg.

(Key words: nuclear polyhedrosis virus, Spodoptera mauritia, transovum and transovarial transmission)

INTRODUCTION

Although transmission of insect viruses through eggs was generally accepted, it may take place through virus that may be contained within the eggs (transovarial) or on the exterior of the egg (transovum) (MARTIGNONI & MILSTEAD, 1962). Transmission of virus through egg provides an economical and self perpetuating method of insect control and a knowledge of this mode of transmission is of much practical utility. Hence the present investigation was taken up to study the mechanism involved in the transmission of the nuclear polyhedrosis virus of *Spodoptera mauritia* through eggs.

MATERIALS AND METHODS

Two hundred healthy fourth instar larvae of *Spodoptera mauritia* were inoculated with a polyhedral suspension of 48×10^4 PIBS/ml by the leaf feeding technique (LATHIKA & JACOB, 1974). Another set of 100 larvae of the same age group fed with untreated grass served as control. Both inoculated and control larvae were reared under aseptic conditions. The moths on emergence were grouped in batches of five pairs in glass battery jars for egg laying. Ten per cent sucrose solution in cotton swabs was provided as food for adults. Eggs obtained from moths of virus treated and untreated larvae were used for further studies.

Experiment I:

One batch of eggs of moths emerged from virus treated larvae was surface sterilized by soaking in 10 per cent formalin for one hour (HENNEBERRY & KISHABA, 1966). Another batch of eggs was left unsterilized. Three replications of 100 eggs each from the sterilized and unsterilized batches were kept for hatching and further observations on virus infection in the larval stages. An equal number of eggs obtained from moths emerged from untreated larvae were kept without surface sterilization as control. The larvae were reared individually; observations were recorded on larval and pupal mortality due to NPV and adult emergence.

Experiment II:

Eggs obtained from moths developed from virus treated larvae were divided into two batches. The first batch was thoroughly homogenised in a mortar and pestle, filtered through cheese cloth, and the filtrate made upto a known volume by adding sterile distilled water. The second batch of eggs was surface sterilized in 10 per cent formalin for one hour and the homogenate prepared as before. The viral activity of both egg homogenates was tested against third instar larvae by feeding them with grass contaminated with these egg homogenates. Similar set of larvae fed on leaves dipped in distilled water alone served as control. The treated and untreated larvae were reared individually. There were five replications with 30 larvae per treatment. Observations were recorded on larval and pupal mortality due to NPV and adult emergence.

Experiment III:

Adults developed from disease-free larvae were used in this experiment. Each pair was confined in a wide mouthed glass bottle. The mouth of the bottle was covered with a nylon net over which was placed a cellophane disc of 5 cm diameter with a 2 mm hole punched in its centre. Cotton swab soaked in a polyhedral suspension containing 48×10^6 PIBS/ml in 10 per cent sucrose solution was placed on the cellophane disc and covered with one half of a petridish to prevent drying of the cotton swab. The moths were found feeding on the food provided in this manner. This method of feeding helped to avoid contamination of the body of the moth with the polyhedral suspension. Moths fed similarly on 10 per cent sucrose solution alone served as control. Thirty eggs collected at random from each pair was surface sterilized in 10 per cent formalin for one hour. Another set of 30 eggs collected at random from each virus fed moth was kept without surface sterilization. Thirty eggs each from the control moths were also collected and kept for hatching. Larvae developed from each group were reared separately for observation on disease incidence.

Experiment IV:

Ten gravid moths developed from healthy larvae reared under aseptic conditions were selected. A polyhedral suspension of 48×10^6 PIBS/ml containing 0.1 per cent teepol as wetting agent was smeared on the abdominal tips of five female moths using a camel hair brush. Abdominal tips of the other five moths were smeared with 0.1 per cent teepol alone to serve as control. Both groups of moths were then confined separately for egg laying. Eggs from the first egg mass laid by each contaminated moth were divided into two batches of 30 each. One batch in each case was surface sterilized in 10 per cent formalin for one hour and the emerging larvae were reared individually. An equal number of eggs collected from uncontaminated moths was also kept for hatching and the larvae were reared individually. Observations were recorded on larval and pupal mortality and adult emergence.

RESULTS

Table 1 gives the per cent larval and pupal mortalities and adult emergence from eggs laid by moths developed from virus treateted larvae. It is seen that there was only 1.36 per cent larval mortality due to NPV when the eggs were surface sterilized while there was only 29.66 per cent larval mortality due to NPV when the eggs were left unsterilized. No mortality due to NPV was observed in control.

Results of feeding *S. mauritia* larvae with homogenates of surface sterilized and unsterilized eggs of moths developed from virus treated larvae are presented in Table 2. The data show that feeding the larvae with homogenates of surface sterilized eggs caused only 2.67 per cent mortality due to NPV. But when homogenate of unsterilized eggs were fed to the larvae the mortality due to NPV increased to 30 per cent. There was no mortality due to NPV in control larvae fed with egg homogenate of healthy virus-free moths.

The data presented in Table 3 show the incidence of NPV in the progeny

of virus-fed moths. The larval and pupal mortalities due to NPV were 14.29 per cent and 2.04 per cent respectively when the eggs were surface sterilized. There was no mortality due to NPV in the larvae hatched out from sterilized eggs and in the control group.

Table 4 presents data on disease incidence in the progeny when the females were contaminated with the virus. A larval mortality of 36.73 per

TABLE 1. Incidence of nuclear polyhedrosis in the larvae hatched out from surface sterilized and unsterilized eggs of *Spodoptera mauritia.*

Treatment	No. of eggs treated	No. of eggs hatched	Per cent larval mortality due to		Per cent pupal mortality due to		Per cent adult emergence
			NPV	Other causes	NPV	Other causes	
1. eggs from moths treated with NPV in their larval stage							
a. Surface sterilised	300	295	1.36	0.68	—	—	97.96
b. Unsterilized	300	290	29.66	1.38	4.48	—	64.48
2. Eggs from virus-free healthy moths (control)	300	295	—	—	—	0.34	98.30

TABLE 2. Incidence of nuclear polyhedrosis in third instar larvae of *S. mauritia* fed with sterilized and unsterilized egg homogenates.

Treatment	No. of larvae in the test	Per cent larval mortality due to		Per cent pupal mortality due to		Per cent adult emergence
		NPV	Other causes	NPV	Other causes	
1. Homogenate of eggs from moths treated with NPV in their larval stages						
a. Surface sterilised egg homogenate	150	2.67	2.00	—	—	95.33
b. Sterilized egg homogenate	150	30.00	3.33	4.00	—	62.67
2. Egg homogenate from healthy virus free moths (Control)	150	—	2.67	—	0.66	96 67

TABLE 3. Incidence of nuclear polyhedrosis in the progeny of virus fed moths of *S. mauritia*.

Treatment	No. of eggs in the test	No. of eggs hatched	Per cent larval mortality due to		Per cent pupal mortality due		Per cent adults emergence
			NPV	Other causes	NPV	Other causes	
1. Eggs from virus fed moths							
a. Surface sterilized	150	146	—	1.37	—	—	98.63
b. Unsterilized	150	147	14.29	2.04	1.36	—	82.31
2. Eggs from healthy virus free moths	150	147	—	1.36	—	—	98.64

TABLE 4. Incidence of nuclear polyhedrosis in the progeny when genitalia of female moths of *S. mauritia* were contaminated with the virus.

Treatment	No. of eges in the test	No. of eggs hatched	Per cent larval mortality due to		Per cent pupal mortality due to		Per cent adult emergence
			NPV	Other causes	NPV	Other causes	
1. Eggs from virus contaminated adults							
a. Surface sterilised	150	148	—	0.67	—	—	99.33
b. Unsterilized	150	147	36.73	1.36	—	—	61.91
2. Eggs from virus-free healthy moths (Control)	150	149	—	1.34	—	—	98.66

cent due to NPV was recorded when the eggs of virus contaminated moths were left unsterilized. No death due to viral infection was recorded when the eggs were surface sterilized. There was no disease incidence in control also.

DISCUSSION

Observations made with eggs of moths treated with NPV in their late larval stages showed that a portion of the population of the emerging larvae succumbed to viral infection when the

eggs were not surface sterilized while only negligible mortality occurred when they were surface sterilized. Similar results were obtained when larvae were fed with surface sterilized and unsterilized egg homogenates of such moths. This indicated that the case of *S mauritia* transmission of the virus took place through surface contamination of eggs with the virus i e., transovum transmission. The larvae on hatching come out of the egg by cutting open the egg chorion and in this way acquire the virus inoculum that is present on the egg.

The very low percentage of larval mortality due to NPV even when the eggs were surface sterilized as observed in the present studies might be due to incomplete sterilization resulting in the presence of traces of active virus on the egg surface. DOANE (1969) favoured this view rather than attributing it to transovarial transmission. But several earlier workers have raised the possibility of transovarial transmission in such instances (HARPAZ & BENSHAKED, 1964; PAWAR & RAMAKRISHNAN, 1971; NEELGUND & MATHAD, 1978). ROEGNER-AUST (1950) observed dissolution of polyhedra in the lymph of *Bombyx mori* and *Lymantria monacha* pupa and concluded that such freed virus particles could penetrate the eggs in ovaries resulting in transovarial transmission. VAIL & GOUGH (1973) detected viral particles in the ovaries of virus infected cabbage looper pupae. Histopathological observations in *S. mauritia* by the author (unpublished) showed viral infection of the epithelial lining of the gonads. These observations point to the possibility of transmission of NPV within the eggs (transovarial) when infection occurred in the larval stages. The evidence gathered in the present investigation also is not conclusive enough to rule out the possibility of transovarial transmission.

The results of experiments on viral transmission through virus-fed adults showed that they transmitted the virus to a section of their progeny (14.29 per cent). When the female genitalia were contaminated with the virus the incidence of the disease in the progeny was 36.73 per cent. In both cases transmission of the virus to the progeny could be completely eliminated through surface disinfection of eggs indicating transmission through transovarum route. Similar results were obtained by applying virus paste to the external genitalia of the females of *Colias eurytheme* and *Trichplusia ni* (MARTIGNONI & MILSTEAD, 1962; ELMORE & HOWLAND, 1964) and also by feeding the cabbage looper moths with the polyhedral suspension (VAIL & HALL, 1969). HAMM & YOUNG (1974) demonstrated the presence of polyhedra on the surface of the eggs of virus-fed *Hyphantria cunea* using scanning electron microscope.

It is evident from the results of experiments using virus-fed moths and virus contaminated moths that transmission of the virus to the progeny took placy only through surface contamination of eggs. Such external contamination of eggs might have taken place by the virus that had been passed through the digestive tract and excreted or by the virus that was smeared on the genitalia contaminating the egg surface during the egg laying process. It has also been indicated that moths treated with the virus in their late larval stages could transmit the virus mainly through surface contamination

and possibly also transovarially. However, transmission through transovarial route was negligible in this case. These observations clearly suggest that in *Spodoptera mauritia* transmission of NPV from parent to progeny takes place mainly through the transovum route.

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THE DIFFERENTIAL EFFECTS OF SELECTED FUMIGANTS ON THE MULTIPLICATIVE POTENTIAL OF *RHYZOPERTHA DOMINICA* F. (COLEOPTERA : BOSTRICHIDAE)

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The multiplicative potential of adults of *Rhyzopertha dominica* F. was adversely affected by doses of ethylene oxide giving 11% or more mortality, LD_{95} of methyl bromide and LT_{90} of nitrogen. A dosage of phosphine giving nearly 80% kill and dosage of ethylene dibromide causing more than 55% kill reduced the productivity, respectively, during the first 10 days and subsequent 25 days following treatment. Carbon dioxide had little influence on the multiplicative potential. Mortality of the insects exposed to ethylene dibromide did not reach an end point even 25 days after fumigation. In other cases, a post-treatment period of 10 days was found sufficient.

(*Key words: Rhyzopertha dominica* fumigants, productivity)

INTRODUCTION

The problem of resistance of stored product insects towards various insecticides including fumigants is of serious concern all over the world (CHAMP & DYTE, 1976). In field fumigations of stored products where whole populations of insects are exposed, a small proportion of insects may experience sublethal concentrations, because they are in a physiologically advantageous state of lower susceptibility such as occurs in diapause or at pupation or because they are inherently tolerant to the fumigant. These tolerant survivors may transmit characters of survival value to their progeny and resistant strains may start to develop (UPITIS *et al.*, 1973; BOND & BUCKLAND, 1979). Therefore, a study on the multiplication potential of the survivors of fumigation the probable parent stocks for resistant strains, is very important. There are only a few reports on the reproductive potential of some of the stored products insects exposed to fumigants and controlled atmospheres (LOSCHIAVO, 1960; HOWE & HOLE, 1967; WINKS, 1971; SPRATT, 1979; RAJENDRAN & MUTHU, 1981).

Among insect pests of grain, the lesser grain borer, *Rhyzopertha dominica* F. occupies third position after *Sitophilus oryzae* L. and *Sitotroga cerealella* Olivier (CHAMP & DYTE, 1976). Both adult and larval stages of the insect consume and cause more damage to cereal grains than individuals of *Sitophilus* spp. (GOLEBIOWSKA, 1969). The effects of fumigation with ethylene dibromide, ethylene oxide, mythel bromide, phosphine (hydrogen phosphide), carbon dioxide and nitrogen on the multiplicative potential of adults of *R. dominica* were studied and the results are now reported.

MATERIALS AND METHODS

Cultures of *R. dominica* were maintained on wheat at optimal temperature of 33 ± 2°C (HOWE, 1965) and 50 ± 5% RH. Unsexed adults, 5-8 days old, obtained from these cultures were used at 30 insects per replicate. The insects were held at the test conditions at least for 8 h before treatment. A piece of 1×2 cm size Whatman No. 1 filter paper was placed as a foot-hold for the test insects in 1×7.5 cm test tubes. The open end of the tubes were closed by cloth with small rubber bands and then placed in 288± 5 ml capacity stoppered conical flasks for fumigation. Each flask was provided with a side tube plugged with a rubber septum through which doses of fumigant were injected. Fumigations were carried out for 24 h at the laboratory conditions of 26–29°C and 70–90% RH as described earlier (RAJENDRAN & MUTHU, 1981). Ethylene dibromide, ethylene oxide, methyl bromide, phosphine and carbon dioxide were tested. In an experiment, there were five doses for each fumigant except ethylene dibromide (7 doses) with two replicates per dose plus 3 controls. Experiments were repeated twice for each fumigant.

In the nitrogen experiment, time was taken as the variable. Adults, 30 per replicate in 60 ml capacity stoppered U-tubes were exposed to nitrogen for 24, 48, 72, 96 and 144 h at the laboratory temperature mentioned above. Nitrogen (99.9%) from a cylinder passed through saturated sodium chloride solution was allowed to flow through the U-tubes containing test insects at the rate of one litre per minute for 10 min to replace the ai completely. In controls, the flasks were flushed with air for the same period. For each exposure period, there were 3 or 4 replicates.

Following treatment with nitrogen or other fumigants, the insects were transferred to 2.5 × 10 cm test tubes containing 20 g wheat. Counts were made again after 15, 25 and 35 day post-treatment after which the survivor were discarded. All the tubes containing insects were kept at the rearing temperature and humidity except during data collections Final mortality was calculated after necessary correction for natural control mortality. When emergence of the F_1 adults started, they were counted and removed every four days till no more could be found. Productivity (progeny produced per adult-day) was estimated according to KAZMAIER & FULLER (1959). The values, which followed a Poisson distribution, were transformed into square-roots and an analysis of variance followed by Duncan's multiple range test (DUNCAN, 1955) was carried out. No statistical analysis was done for the data from nitrogen experiments.

RESULTS AND DISCUSSION

The multiplication potential of *R. dominica* surviving treatment varied depending on the fumigant and its dosage (Table 1). Further, the productivity data for the first 10 days and next 25 days indicated that none of the fumigants caused a consistent reduction in the multiplication capacity of the survivors for both the intervals. Ethylene oxide reduced the productivity even at a dose of 1 mg/l producing only 11% kill. A similar inhibitory effect was observed at the LD_{50} level in *Tribolium castaneum* and *S. oryzae* (RAJENDRAN & MUTHU, 1981) but not in *Trogoderma granarium* Everts exposed to a range of doses (RAJENDRAN, 1982). Higher doses of ethylene oxide affected the reproduction potential of *Acanthoscelides obtectus* say (HERRICK & HORSFALL, 1931). The oviposition of adults of *T. granarium* L. was affected by methyl bromide at 20 and 32.5 mg h/l doses (BRUDNAYA *et al.*, 1966; HOWE & HOLE, 1967). In the present study, only the highest dose of 1 mg/l (LD_{95}) could reduce the productivity of *R. dominica*. Nevertheless, *S. oryzae*, *T. castaneum* and *T. granarium* showed normal productivity after exposure to methyl bromide (RAJENDRAN & MUTHU, 1981; RAJENDRAN, 1982)

Ethylene dibromide has been reported to cause a depressing effect on the fertility or productivity of *Tribolium* spp.

TABLE 1. The productivity of *R. dominica* surviving exposure to fumigants.

Fumigant	Dose (mg/l)	Final corrected mortality † (%)	productivity** (progeny produced/adult-day) mean ± S E		
			During first 10 days	Next 25 days	Total
Ethylene dibromide	0.40	36.9	0.35 ± 0.10 *a*	0.09 ± 0.04 *ab*	0.20 ± 0.07 *a*
	0.60	67.3	0.37 ± 0.10 *a*	0.11 ± 0.004 *ab*	0.22 ± 0.08 *a*
	0.80	54.4	0.36 ± 0.10 *a*	0.09 ± 0.04 *ab*	0.19 ± 0.07 *a*
	1.00	56.0	0.31 ± 0.09 *a*	0.13 ± 0.05 *ab*	0.21 ± 0.08 *a*
	1.20	68.5	0.25 ± 0.08 *a*	0.07 ± 0.04 *ab*	0.16 ± 0.07 *a*
	1.40	95.5	0.27 ± 0.08 *a*	0.02 ± 0.01 *b*	0.20 ± 0.06 *a*
	1.60	98.2	0.26 ± 0.07 *a*	0.02 ± 0.02 *b*	0.17 ± 0.06 *a*
Ethylene oxide	0.25	10.1	0.52 ± 0.12 *a*	0.17 ± 0.06 *a*	0.28 ± 0.09 *a*
	0.50	7.3	0.47 ± 0.11 *a*	0.14 ± 0.06 *a*	0.25 ± 0.08 *a*
	1.00	11.1	0.24 ± 0.08 *b*	0.07 ± 0.04 *a*	0.13 ± 0.06 *b*
	1.25	59.0	0.02 ± 0.02 *c*	0.07 ± 0.04 *a*	0.05 ± 0.03 *bc*
	1.50	76.6	0.01 ± 0.01 *c*	0.12 ± 0.05 *a*	0.08 ± 0.04 *c*
Methyl bromide	0.60	6.3	0.27 ± 0.09 *a*	0.15 ± 0.06 *a*	0.19 ± 0.07 *a*
	0.70	34.9	0.55 ± 0.12 *a*	0.24 ± 0.07 *a*	0.35 ± 0.10 *a*
	0.80	53.5	0.67 ± 0.13 *a*	0.29 ± 0.08 *a*	0.44 ± 0.11 *a*
	0.90	77.3	0.72 ± 0.14 *a*	0.34 ± 0.07 *a*	0.49 ± 0.11 *a*
	1.00	95.2	0.22 ± 0.05 *b*	0.01 ± 0.01 *a*	0.09 ± 0.03 *b*
Phosphine	0.002	2.2	0.36 ± 0.10 *a*	0.15 ± 0.06 *a*	0.23 ± 0.08 *a*
	0.004	5.0	0.44 ± 0.11 *a*	0.24 ± 0.06 *a*	0.28 ± 0.09 *a*
	0.008	34.2	0.56 ± 0.12 *a*	0.25 ± 0.07 *a*	0.36 ± 0.10 *a*
	0.012	70.3	0.40 ± 0.10 *a*	0.22 ± 0.06 *a*	0.29 ± 0.09 *a*
	0.016	79.4	0.24 ± 0.08 *b*	0.15 ± 0.05 *a*	0.18 ± 0.06 *a*
Carbon dioxide	40*	8.6	0.28 ± 0.09 *a*	0.15 ± 0.06 *a*	0.19 ± 0.07 *a*
	50*	25.2	0.33 ± 0.09 *a*	0.16 ± 0.06 *a*	0.21 ± 0.08 *a*
	60*	74.8	0.48 ± 0.11 *a*	0.30 ± 0.08 *a*	0.37 ± 0.10 *a*
	70*	84.5	0.74 ± 0.13 *a*	0.74 ± 0.11 *a*	0.74 ± 0.13 *a*
	80*	95.7	0.43 ± 0.06 *a*	0.38 ± 0.06 *a*	0.39 ± 0.07 *a*
Control	—	(6.8)	0.50 ± 0.03 *a*	0.16 ± 0.04 *a*	0.28 ± 0.06 *a*

* The percentage of carbon dioxide.

† Based on mortality counts at 35 days post treatment for ethylene dibromide (36.5% control mortality) and after 10 days in other cases (6.8% control mortality).

** Mean of 9 replicates in control and 6 in treated. Means followed by different letters differ significantly at 5% (ethylene dibromide) or 1% level (in others) by Duncan's new multiple range test.

and *S. oryzae* (LOSCHIAVO, 1960; RAJENDRAN & MUTHU, 1981). However it did not produce a similar effect in *R. dominica* either during the first 10 days or for the total holding period of 35 days (Table 1). In contrast, phosphine at 0.016 mg/l (LD_{79}) lowered the productivity during the initial holding period of 10 days only. The effects of the first 10 days or later 25 days was probably inadequate to influence over the total of 35 days production in phosphine or ethylene dibromide treated insects. In *T. castaneum* Herbst, WINKS (1973) observed that the reproductive capacity of the adults exposed to phosphine at 0.012 mg/l was affected immediately after the treatment but it returned to normal by 12th day. However, there was marked inhibition of reproduction when adults were exposed at higher concentrations. As the toxic action of phosphine is lowered in a nitrogen atmosphere, KASHI (1981) observed normal fertility of some stored products insects including *R. dominica* fumigated with phosphine in nitrogen.

There are reports on carbon dioxide, a toxic atmospheric gas, indicating its adverse effect on the fecundity of stored products insects (JANISCH, 1924; LUM & FLAHERTY, 1972; SPRATT, 1979) but *R. dominica* adults in this work were normal in multiplication even after exposure to 80% carbon dioxide achieving 96% kill. Similarly, carbon dioxide did not influence the productivity of *T. granarium*, a tolerant species (RAJENDRAN, 1982). Nitrogen, however, which is often less toxic than carbon dioxide to insects significantly reduced the progeny production of *R. dominica* adults exposed for 72 h (Table 2). Generally, disinfestation of stored wheat or corn using a nitrogen atmosphere requires an

TABLE 2. The productivity of *R. dominica* surviving exposure to a nitrogen atmosphere.

Exposure period (h)	Corrected mortality* (%)	Productivity** (mean No. and range of progeny produced/adult day)					
		During first 10 days		Subsequent 25 days		Total	
		Control	Fumigated	Control	Fumigated	Control	Fumigated
24	18.4 (10.1)	0.55 (0.45–0.65)	0.55 (0.37–0.78)	0.10 (0.08–0.11)	0.04 (0–0.07)	0.26 (0.24–0.29)	0.23 (0.19–0.28)
48	67.4 (3.5)	0.40 (0.19–0.54)	0.34 (0.12–0.70)	0.17 (0.01–0.28)	0.21 (0–0.37)	0.25 (0.19–0.36)	0.26 (0.22–0.32)
72	89.7 (67.4)	0.76 (0.50–1.10)	0.04 (0–0.13)	0.18 (0–0.33)	0.14 (0–0.42)	0.51 (0.29–0.69)	0.10 (0–0.29)
144	100 (80.0)	–	–	–	–	–	–

* Based on mortality counts 10 days following treatment. Natural control mortality in parantheses.

** Mean of 3 or 4 replicates.

exposure period of more than 10 days. The ability of nitrogen to impair the productivity of *R. dominica* is noteworthy.

After phosphine, the most toxic fumigant to *R. dominica* adults were methyl bromide and ethylene dibromide. In bioassays of fumigants, a holding period of 14 days has been recommended for end point mortality, although with some fumigants, the mortality may stabilise earlier (CHAMP & DYTE, 1976). With ethylene dibromide, the mortality of the insects did not stabilise even after 25 days (Table 3). In other cases, a holding period of 10 days was sufficient for the mortality to reach an end point. However, lower doses of these fumigants causing less than 20% kill required a longer period of 25 days to arrive final mortality. Also, nitrogen with a 24 h exposure period caused 18% kill assessed after 10 days, rising to 30% at the end of 25 days. WINKS (1973) noted that the time to reach the end point mortality increased with increasing concentrations of phosphine for *T. castaneum*.

The data in the present study indicate that adults of *R. dominica* surviving treatment with atmospheric gases or other fumigants except ethylene oxide can multiply at the usual pace and under the selection pressure the subsequent generations may develop resistance

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TABLE 3. Mortality of *R. dominica* adults arrived at various time intervals following exposure to fumigants.

Fumigant	Dose (mg/l)	Corrected mortality** arrived at indicated days following treatment (%)				
		5	10	15	25	35
Ethylene dibromide	0.40	2.8	0.6	3.6	38.3	36.9
	0 60	4.7	1.4	5.1	54.8	67.3
	0 80	5.8	5.4	7.1	41.1	54.4
	1.00	8.5	6.6	13.9	33.7	56.0
	1.20	27.7	33.8	44.6	57.4	68.5
	1.40	62.1	67.9	73.8	91.1	95.5
	1 60	64.4	66.6	71.6	87.9	98 2
Ethylene oxide	0 25	12.0	10.1	12.0	14.8	10.7
	0.50	8.3	7.3	9.7	12.7	6.4
Methyl bromide	0 60	9.4	6.3	5.2	13.8	0
Phosphine	0 002	2.8	2.2	2.8	12 9	0 7
Carbon dioxide	40*	11 8	8.6	10 0	19.9	15.1
Control	—	(0 6)	(6.8)	(9.0)	(15.9)	(36.5)

* The percentage of carbon dioxide.

** Mean of 9 replicates in control and 6 in treated.

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AMINOTRANSFERASE ACTIVITIES IN THE DEVELOPING EGGS OF TWO SILKWORM RACES (*BOMBYX MORI* L.)

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Both diapausing (*NB_{18}*) and non-diapausing (*Mysore pure*) eggs of *Bombyx mori* L contained active amino transferase activities. Alanine amino transferase (ALAT) (EC 2.6.1.2) activity was higher than that of aspartate amino transferase (AAT) (EC 2.6.1.1). Non-diapausing eggs described an initial decrease in the AAT and ALAT activities (upto 72 h after oviposition) and then a non-linear (hyperbolic) increase (upto 216 h after oviposition) with reference to development. In diapausing eggs the activity was more or less stable. Acid treatment of the diapausing eggs described the same trends as those of non-diapausing eggs. The importance of the enzyme with reference to development of the embryo is discussed.

(*Key words:* diapause, eggs, *Bombyx mori*, silkworm, aminotransferase)

INTRODUCTION

Considerable amount of information is available regarding the enzyme pattern and activity of the developing embryos of the silkworm, *Bombyx mori* L. Most of these studies were with reference to the carbohydrate and lipid metabolism of both diapausing and non-diapausing embryos of the silkworm (KAI & HASEGAWA, 1972; 1973; KAI & HAGA, 1978; SUZUKI & MIYA, 1977; YAGINUMA & YAMASHITA, 1977; 1978; NAKASONE, 1979). However, the protein metabolism of the developing egg is not very well understood. Although the silkworm egg is known to be a centrolecithal cleidoic egg like that of any other insect, the yolk proteolysis may not yield all the amino acids required (AGRELL & LUNDQUIST, 1973) for newer protein synthesis during development. Many amino acids are to be synthesized during the course of development and incorporated into the newer proteins that appear during embryonic differentiation. Side group transfer and transaminations are the main pathways for the synthesis of newer amino acids in any living cell (ORTEN & NEUHAUS, 1970). It is interesting to compare the enzyme activities of such pathways which result in the synthesis of newer amino acids in the development process. The present investigation is directed to study the amino transferase activity in the diapausing and non-diapausing eggs of the silkown *Bombyx mori* L. as amino-transferases bring forth transaminations of amino-acids with keto acids.

MATERIALS AND METHODS

Eggs laid by a single moth (cellular layings) were collected from each of the two races of silkworm *Bombyx mori* L. One of these two is *Mysore pure* race with multivoltine characteristics, the other one being *NB_{18}* a bivoltine rarce propagated ie Karnataka state

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Both the layings were reared under identical conditions (Chawki at 28 ± 2°C and 80% RH; Worms at 25 ± 2°C and 75% RH) on mulberry leaf belonging to *M5* variety. After moth emergence the unirace sexes were paired and loose layings were obtained. The bivoltine eggs were divided into two batches, and one was treated with hot (46°C) hydrochloric acid of 1.085 sp g for 5 minutes at 20th hour of development, the other batch was allowed to diapause at room temperature. Eggs from 1 to 9 days after oviposition were used for assays.

A sample of 500 pooled eggs from two or three moths of bivoltine or multivoltine race were homogenized separately in 10 ml 0 1 M phosphate buffer pH 7.4. Pyridoxal phosphate (0.2 mg 10 ml) was added to the mixture while homogenising. The homogenate was centrifuged at 3000 g at 4°C for 10 minutes and the supernatent was used as the enzyme source. The protein of the homogenate was estimated colorimetrically (LOWRY *et al.*, 1951). For each observation ten such moth samples were assayed.

The alanine amino and aspartic aminotransaminases (EC 2.6.1 2 & EC 2.6.1.1 respectively) were assayed in the homogenate colorimetrically according to REITMAN & FRAENKEL (1957). Usually, replicative samples were run to obtain concurrent results. The enzyme activity was expressed as nanomoles keto acid formed due to transamination per minute per mg of homogenate protein.

RESULTS AND DISCUSSION

The results are summarized in Figs. 1 and 2.

The alanine amino transferase (ALAT) showed a higher specific activity than that of aspartate amino transferase (AAT) in the developing embryo of both non-diapausing and diapausing races. In non-diapausing embryo the activity increases hyperbolically maintaining a minimal activity at 72 h after oviposition for AAT and 48 h for ALAT. In the diapausing embryos the activity of both the enzymes reduced to a minimal level in 24 h which remained more or less the same later

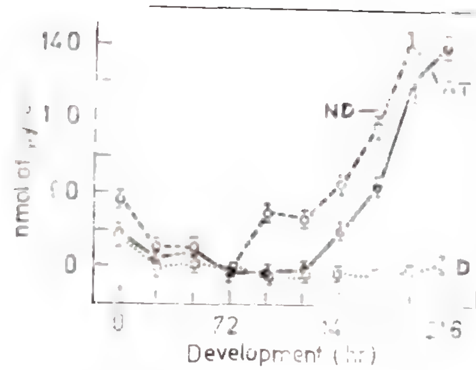

Fig. 1. Alamine aminotransferase activity in the developing eggs of *Bombyx mori*. Plots are mean ± SD (n=10).
D—Diapausing eggs (bivoltine NB_{18} race); AT—Acid treated eggs of NB_{18}; ND—Non-diapausing eggs (Multivoltine, *Mysore pure* race).

until 212 h (multivoltine race eggs usually hatch out earlier). AAT however seems to be more stable (cf. Fig. 2 with Fig. 1) in diapausing eggs. Acid treated eggs showed the same trend as that of non-diapausing eggs.

Two noteworthy observations can be made from these results. First by the results illustrate how the acid treatment triggers the steady aminotransferase activity which usually increases with development in non-diapausing eggs. Secondly, the results draw an analogy between the aminotransferase activity and the existing model of RNA synthesis in the developing embryo (KURATA & SAKAGUCHI, 1978).

AAT, the enzyme linking carbohydrates and protein metabolism, has been strongly implicated in the production of energy in animal tissues and is also considerd as a stress indicator (GOULD *et al.*, 1976; HAMMEN, 1969). It catalyses the inter-conversion of asparate and L-ketoglutarate to oxaloacetate and

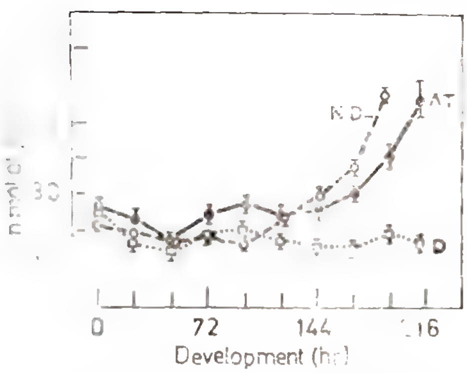

Fig. 2. Asparate aminotransferase activity in the developing eggs of *Bombyx mori*. Plots are mean ± SD (n = 10).

glutamate (VELIC & VAVRA, 1962). AAT is the main transaminase that interferes with tricarboxylic acid cycle in a major way (LOWENSTEIN, 1967). A rise in its activity indicates the occurrence of greater energy demands which are normally associated with synthetic activities of the cell (MEISTER, 1965). MCALLAN & CHEFURKA (1961) showed a close association between high transaminase activity, and growth and development in insects. These authors are of the opinion that as new tissues are formed from the primordial elements, the histoblasts, transamination serves to regulate the supply of amino acids for protein synthesis in these tissues. Thus histogenesis augmented by protein synthesis is related to transmination, which is the main general mechanism for the regulation of balanced amino acid pool required for protein synthesis (AGRELL & LUNDQUIST, 1973).

During embryogenesis most of the free amino acids in the insect egg are formed through degradation of yolk proteins and they are incorporated into the proteins of growing embryo (CHEN, 1966). Some amino acids are however synthesized anew in the insect egg (BUNDE & PEPPER, 1968); balancing the yolk proteolysis, protein synthesis, amino acid synthesis and possibly amino acid degradation (AGRELL & LUNDQUIST, 1973). RNA synthesis will always be proceeding in perfect association with protein synthesis and histogenesis. Intense RNA synthesis starts along with gastrulation of the insect egg (CHEN, 1966). This intense RNA synthesis during the formative period does not appear to continue undiminished till hatching. Protein synthesis begins also early in insect development (AGRELL & LUNDQUIST, 1973).

The aminotransferase activity curves for diapausing and non-diapausing eggs described here resemble those of RNA-synthesis in the developing embryo of the silkworm (KURATA & SAKAGUCHI, 1978). The RNA synthesis in diapausing eggs is very low at the beginning and remains at the same level throughout the diapause (KURATA & SAKAGUCHI, 1978). The non-diapausing and artificially hatching eggs gradually elevate the activity after 2 days of oviposition. According to KURATA & SAKAGUCHI (1978) the onset of this elevation of synthetic activity in artificially hatching eggs is about a day later than that of naturally non-diapausing eggs. The acid treatment triggers the (AAT or ALAT) activity exhibiting the same trend found in a non-diapausing egg. Although this trend of RNA synthesis in the development is identical with that of aminotransferase activity, the inter-relationships of them require clarification although the protein synthesis and RNA synthesis are known to go always hand in hand within the cellular environment and although the former is more related to transaminations.

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FEEDING BEHAVIOUR OF *CHRYSOPA SCELESTES* BANKS ON THE PARASITISED EGGS OF SOME LEPIDOPTEROUS PESTS

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Eggs of three lepidopterous insects, namely *Heliothis armigera* (Hubn), *Earias vitella* (F.) and *Spodoptera litura* (F.) were allowed to be parasitised by *Trichogramma chilonis* Ishii, *T. achaeae* Nagaraja & Nagarkatti and *Telenomus remus* Nixon respectively. These parasitised eggs were offered to the larvae of predator *Chrysopa scelestes* Banks to find out the feeding behaviour. The data revealed that the predator readily attacked the parasitised eggs. The predator larva fed/attacked more number of parasitised eggs as the age of the parasitised egg increased. The predator even damaged the eggs while the parasites were emerging and killed the parasites from such eggs. Release of either egg parasite or *C. sclestes* is suggested to abtain effective control instead of combining both.

(*Key words:* feeding behaviour, *Chrysopa scelestes*)

INTRODUCTION

In recent years lot of emphasis is being bestowed in India towards adoption of non-chemical control, particularly biological control method wherever feasible. The green lace-wings and egg parasites are being mass released in the field for the control of bollworms of cotton, aphids and *Spodoptera litura* (F.) of tobacco etc., in addition to the natural control. Whereas if the predator *Chrysopa scelestes* Banks was released along with egg parasite *Telenomus remus* Nixon for the control of *S. litura*, the former will attack the parasitised eggs too, in addition to the healthy eggs, and thereby reducing fast and good establishment of *T. remus*. In the present study therefore to confirm whether the predator behaved only in one occasion as said earlier or it would behave with other egg parasites too, an experiment was conducted under laboratory conditions. Such study will help to determine whether to augment or inundate either one of the desirable species or both parasite and predator to get effective control in a given agroecosystem.

Contribution No. 365/84 of IIHR, Bangalore-560 089.

MATERIALS AND METHODS

The culture of predator, *C. scelestes* was mass reared on eggs of *Corcyra cephalonica* (Staint.) as described by KRISHNAMOORTHY & NAGARKATTI (1981). For different host eggs, three lepidopterous insects were considered such as *Heliothis armigera* (Hubn), *S. litura* (both were mass reared on artificial diet developed by NAGARKATTI & SATYAPRAKASH (1974) and *Earias vitella* (F.) (mass reared on *okra* fruits). The gravid female moths of *H. armigera* and *E. vitella* were allowed to lay eggs on muslin while of *S. litura* were to lay egg masses on paper. Three egg parasites viz., *Trichogramma chilonis* Ishii, *T. achaeae* Nagaraja & Nagarkatti (initially maintained on eggs of *C. cephalonica*) and *T. remus* (maintained on

eggs of *S. litura*) were considered for the study.

Cut pieces of muslin which contained known number of freshly laid eggs of *H. armigera* in groups, were kept in individual vials. Known number of *T. chilonis* were introduced into each vial (to avoid superparasitism) and held overnight for parasitisation. The parasites were then removed. The third instar larva of *C. scelestes* was introduced at the rate of one larva per vial in vials containing 1, 3, 5, 7 and 9 day old parasitised eggs. The number of eggs preyed or even partially damaged during 24 h was considered as fully fed and such observation was recorded on five age groups of parasitised eggs. Similarly, *T. achaeae* parasitised eggs of *E. vitella* were exposed to third instar larva of *C. scelestes* and observation was made on four age groups viz., 1, 3, 5 and 7 day old parasitised eggs.

Freshly laid fertilized egg masses of *S. litura* were exposed overnight to adults of *T. remus* for parasitization. Then 1, 3, 5, 7, 9 and 11 day old parasitised egg masses were offered to third instar larvae as described earlier. Parallel experiments were also conducted with healthy eggs of *H. armigera, E. vitella* and *S. litura.* All experiments were carried out at laboratory room temperature of 28 ± 2°C and 55—75% RH.

RESULTS AND DISCUSSION

The extent of predation by the predator, *C. scelestes* on three different host eggs parasitised by three different parasites is furnished in Table I. It was observed that the predator attacked the host eggs parasitised by the different egg parasites. There was initially not much difference on the number of eggs preyed between healthy and one day old parasitised eggs. But the number of eggs damaged by the predator kept increasing with the age of the parasitised eggs. The increase in number of eggs damaged might be due to the resultant development of parasite on the yolk inside the egg and meagre food availability after utilized by the developing embryo to the predator as the age of the parasitised eggs increased. Table I shows that the number of eggs attacked became less in 9 and 11 day old parasitised eggs of *H. armigera* and *S. litura* respectively. This was mainly due to the fact that few parasites had already emerged from the parasitised egg

TABLE 1. Extent of predation of parasitized eggs by *C. scelestes*.

S. No.	Age of healthy/ parasitised eggs offered (days)	*Mean number of parasitized eggs preyed in 24 h in the case of: *T. chilonis*/*H. armigera*	*T. achaeae E. vitella*	*T. remus*/*S. litura*
1	Fresh healthy	138.3 ± 19.04	313.0 ± 15.10	144.0 ± 14.53
2	1	137.0 ± 8.72	307.0 ± 4.36	147.3 ± 17.16
3	3	213.0 ± 13.12	349 0 ± 32 08	205.0 ± 8.19
4	5	240.6 ± 5.69	534.0 ± 27.07	256.0 ± 12.12
5	7	325.6 ± 11.06	634.0 ± 11.53	318.6 ± 14.29
6	9	301.3 ± 14.57	—	368.3 ± 15.04
7	11	—	—	258.0 ± 9.00

* Mean of 3 replicates ± SE.

before they were attacked. The peredator was observed to be attacking parasitised eggs while the parasites were emerging and prevented emergence of parasites from such eggs as the parasites were killed.

AL-ROUECHDI (1981) and AL-ROUECHDI & VOEGELE (1981) had also similarly reported that the predator *Chrysoperla carnea* (Steph.) preyed on the eggs of *Ephestia kuhniella* Zell. parasitised by *T. embryophagum* (Htg.) whatever stage the parasite development had reached and that the chrysopid did not distinguish between parasitised and unparasitised eggs. TREMBLAY (1980) had reported that the predator *C formosa* Br. even attacked the aphids, *Aphis fabae* Scop. and *A. craccivora* Koch. parasitised by the braconid *Lysiphlebus fabarum* (Marshel.) He further reported that no parasites had emerged from such mummified aphids which proved to have been perforated by larvae of the predator *C. formosa*. In the present study also the results thus obtained with *C. scelestes* are in agreement with earlier finding such as the predator attacked (i) indiscriminately both parasitised and unparasitised eggs, (ii) all stages of the parasitised eggs, (iii) the parasitised eggs even while the parasites were emerging. Thus care should be taken to avoid releases of chrysopids in an area where natural egg parasitism is more or where egg parasites are to be mass released, to achieve desirable control. Egg parasites should not also be encouraged in an area where activity of chrysopids are more.

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EFFECT OF SEVERAL PESTICIDES ON EGGS, LARVAE AND ADULTS OF THE GREEN LACE-WING *CHRYSOPA SCELESTES* BANKS

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Level of toxicity of several pesticides to eggs, larvae and adults of the green lace wing, *Chrysopa scelestes* Banks, was assessed under laboratory conditions. Chemicals were tested at dosage recommended to field crops like cotton, tobacco, vegetable, fruits, etc. The eggs were sprayed directly. The larvae and adults were exposed to the filter paper strips impregnated with pesticides on fresh (dry film) residues for 6 h continuously and transferred to a clean vial subsequently for 24 h observation. The pesticides were rated as 0, low, medium and high toxicity based on per cent mortality. The egg stage was little affected by insecticidal sprays but newly hatched larvae were found to be susceptible to organophosphate and carbamate group insecticides. The pesticides endosulfan, dicofol, monocrotophos, phosalone, methyldemeton, phosphamedon, dimethoate, sulphur and dithane were found to be totally innocuous to both larvae and adults while quinalphos, chlorpyriphos, malathion and dichlorvos were highly toxic. Carbaryl and methomyl however produced different level of toxicity to the larval instars, the former produced 100% adult mortality while the latter produced no mortality

(Key words: effect of pesticides, *Chrysopa scelestes)*

INTRODUCTION

Several pesticides are broad spectrum in action and are highly toxic not only to crop pests but also to non-target organisms like parasites and predators. In the absence of such biotic factor, the pest always poses problems and endangers crop production. Further, since many pests have shown resistance to chemical insecticides, emphasis is strongly bestowed in recent years to follow either non-chemical or integrated control programme. The success of such programmes rests largaly on the knowledge of selectivity of pesticides to beneficial arthropods. Many field and laboratory level experiments however have been carried out to study the effect of pesticides on beneficial arthropods (BARTLETT, 1964; LINGREN & RIDGWAY, 1967; LAURANCE, 1974; WILKINSON *et al*, 1675), not many studies were conducted with species of chrysopids, particularly in India. The effect of pesticides on species of chrysopids studied elsewhere (PUTMAN, 1956; BARTLETT, 1964; LAWRENCE *et al.* 1973; PLAPP & BULL, 1978) cannot be interpreted for other species because inter- and intra-specific differences in response of beneficial arthropods to pesticides exists, each species of chrysopids should be studied separately to determine its

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tolerance to the pesticides used in the agroecosystem where this species is predominant (BARTLETT, 1964; LINGREN & RIDGWAY, 1967).

In the present study the predator *Chrysopa scelestes* Banks. a predominant species in cotton agro-ecosystem was chosen to determine the effect of chemical pesticides on various stages of green lace-wing under laboratory conditions. The results of this experiment summarised hereunder on chemicials that are non-toxic to minimal toxic to the predator tested will be highly useful to incorporate in integrated control programme.

MATERIALS AND METHODS

The culture of green lace-wing *C. scelestes* was maintained since 1979 on eggs of *Corcyra cephalonica* (Staint.) in the laboratory as described by KRISHNAMOORTHY & NAGARKATTI (1981). As the laboratory culture was not any time subjected to pesticides, the reared adults were considered as susceptible. The predator *C. scelestes* since being tried against pests of tobacco, vegetables, fruits, etc., several pesticides (used in different agro-eco systems) were considered. The pesticides were used at concentration normally recommended to the pests by diluting them in water. The list of pesticides testd, trade name, formulation and concentration are furnished in Table 1.

The pesticides were sprayed directly on to the eggs as suggested by BARTLETT (1964) with slight modification. The egg bearing paper was removed from the oviposition cage and cut into three small pieces containing 50 eggs each. Each piece was then stuck at the base (inside) of the lid of ventilated plastic container. Desired concentration of the chemical was directly sprayed on the lid containing eggs, using a glass atomiser. Forzen eggs of *C. cephalonica* were dispensed

TABLE 1 List of pesticides tested against eggs, larvae and adults of *C. scelestes*.

Sl. No.	Pesticide	Trade name	Formulation	Concentration tested (%)
1.	Endosulfan	Thiodan	35 EC	0.07
2.	Dicofol	Kelthane	18.5 EC	0 05
3.	Monocrotophos	Nuvacron	40 EC	0.05
4.	Phosalone	Zolone	35 EC	0.05
5.	Quinalphos	Ekalux	25 EC	0.05
6.	Chlorpyriphos	Dursban	20 EC	0.05
7.	Methyldemeton	Metasystox	50 EC	0.05
8	Phosphamedon	Dimecron	100 EC	0.05
9.	Malathion	Cythion	50 EC	0.10
10.	Dimethoate	Rogar	30 EC	0.05
11.	Dichlorvos	Nuvan	100 EC	0 05
12.	Carbaryl	Sevin	50 WP	0.10
13.	Methomyl	Lanate	20 EC	0.05
14.	Sulphur	Sulfovit	80 WP	0.16
15.	Dithane	Dithane Z-78	78 WP	0.16

into the container as food material, for larvae that would hatch out, before the lid was replaced on to the container after 30 minutes shade drying. Enough care was taken to see that the eggs were hanging on their stalks inside the container without touching each other. The number of green eggs observed second day after treatment was considered as unfertilized (colour of fertilized eggs would charge to greyish brown due to embryonic development) and removed. A check was maintained where tap water alone was sprayed. After larvae have hatched in check treatment the number of eggs where larvae were unhatched was considered as aborted (embryonic development will be there but die subsequently). The same measure was adopted for other treatments also.

The larvae and adults were exposed to pesticide treated filter paper as suggested by WILKINSON *et al.* (1975) with a little modification. A filter paper strip (6.0×2.5 cm) impregnated in desired concentration of the pesticide was held in shade for 30 minute for drying before introduced into a clean glass vial (7.5×5.2 cm). Sufficient quantity of frozen eggs of *C. cepahlonica* was dispensed into each vial before larva was introduced. Care was taken to avoid touching of eggs with the treated filter paper. A few hours to one day old well—fed 10 first instar larvae were introduced into vial and mouth was closed using muslin cloth for aeration. The larvae were first continuously exposed to the treated surface for 6 h and later the live larvae were transferred to a new clean glass vial with food for further 24 h for post-treatment observation (GAITONDE, 1978). Observations were made at 6th hour of continuous exposure period and 24th hour of post treatment. Similar studies were conducted with second and third instar larvae. A check was also maintained. The larvae that are moribund were considered as dead to for computation of per cent mortality due treatment.

Similarly adults were also exposed to the pesticide treated filter paper. In each vial 10 adult gravid females were introduced and fed with 40% honey. Care was taken to see that the treated filter paper was not touching the honey swab. Observations were also made similar to that of larvae.

In all above experiments, the treatments were replicated three times. Zero values in the mortality were converted into 0.01 and the data were trarsformed into corresponding angles (Arc. sine percentage) for statistical analysis. 'F' test was used to analyse the differences in the mortality of the predator due to different treatments. All studies were conducted at laboratory room temperature of 29±2°C.

RESULTS

The data on the contact toxicity of pesticides to eggs of *C. selestes* thus obtained are furnished in Table 2. The pesticidal application directly on the eggs, did not prevent the larval hatchability in toto. In all treatments 100% hatchability was observed. But such hatched out larvae were all found to be 100% susceptible to pesticides except endosulfan, dicofol, phosalone, sulphur and dithane. Dimethoate alone caused 46.6% larval mortality.

The effect of pesticides on different larval instars is presented in Table 3. The pesticides such as endosulfan, dicofol, monocrotophos, phosalone, phosphamedon, dimethoate, sulphur and dithane were found to be totally innocuous to first, second and third instar larvae. Though there was no first instar larval mortality with methyldemeton and methomyl during 6 h treatment period, mortality subsequently rose to 6.6 and 90.0% respectively during 24 h post-treatment period. The other chemicals viz., quinalphos, chlorpyriphos, malathion dichlorvos and carbaryl have caused 100% mortality in fist instar larvae. The second and third instar larvae have exhibited resistance to methyldemeton and tolerance to malathion, carbaryl and methomyl. Though 100% mortality with malathion was there in second instar during 6 h exposure period itself, the mortality reduced to 70.0% in third

TABLE 2. Effect of pesticides of eggs of *C sceiestes*

Sl. No.	Pesticide	Total No. of eggs sprayed per 3 replicates (A)	Total no. of un-fertilized eggs/3 replicates (B)*	Total no. of aborted eggs per 3 replicates (C)**	Total no. of fertilized eggs per 3 replicates (A – B+C)	Total no. of larvae hatched	mortality in egg stage (%)
1.	Endosulfan	156	8	7	141	141	0.0 (0.57)
2.	Dicofol	99	9	8	82	82	0.0 (0.57)
3.	Monocrotophos	161	7	13	141	141	0.0 (0.57)
4.	Phosalone	130	15	14	101	101	0.0 (0.57)
5.	Quinalphos	158	20	8	130	130	0.0 (0.57)
6.	Chlorpyriphos	117	19	43	55	55	0.0 (0.57)
7.	Methyldemeton	136	17	20	99	99	0.0 (0.57)
8.	Phosphamedon	111	8	14	89	89	0.0 (0.57)
9.	Malathion	151	27	23	101	101	0.0 (0.57)
10.	Dimethoate	147	17	12	118	118	0.0 (0.57)
11.	Dichlorvos	155	17	22	116	116	0.0 (0.57)
12.	Carbaryl	162	13	7	142	142	0.0 (0.57)
13.	Methomyl	139	21	17	101	101	0.0 (0.57)
14.	Sulphur	143	9	8	126	126	0.0 (0.57)
15.	Dithane	116	16	17	83	83	0.0 (0.57)
16.	Control	199	33	35	131	131	0.0 (0.57)

* Based on green colour 2nd day after spraying; ** Based on black colour (after embryonic development was noticed).

TABLE 3 Mortality in different larval instars and adults of *C. scelestes* due to pesticides.

Sl. No.	Pesticide	Percent mortality in							
		I instar		II instar		III instar		Adult	
		6h*	24h**	6 h	24 h	6 h	24 h	6 h	24 h
1.	Endosulfan	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)
2.	Dicofol	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)
3	Monocrotophos	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)
4.	Phosalone	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)
5.	Quinalphos	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)
6.	Chlorpyriphos	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)
7.	Methyldemeton	0.0 (0.57)	6.66 (12.86)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)
8	Phosphamedon	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)
9.	Malathion	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	66.6 (55.56)	70.0 (57.37)	100.0 (90.0)	100.0 (90.0)
10.	Dimethoate	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)
11.	Dichlorvos	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)
12.	Carbaryl	100.0 (90.0)	100.0 (90.0)	40.0 (40.02)	86.6 (72.67)	0.0 0.57	26.6 (34.46)	100.0 (90.0)	100.0 (90.0)
13	Methomyl	0.0 (0.57)	90.0 (79.94)	0.0 (0.57)	56.66 (49.38)	0.0 0.57	20.0 (26.57)	0.0 (0.57)	0.0 (0.57)
14.	Sulphur	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)
15.	Dithane	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)	0.0 (0.57)
	C D (P = 0.05)	Between treatment	3.70		3.48		2.69		

* During continuous exposure. ** During post treatment. Figures in paranthesis are transformed values.
CD value (P = 0.05) 3.70 3.48 2.69

instar even after 24 h post-treatment. The insecticides carbaryl and methomyl have caused less mortality in (26.66 and 20.00%), third instar compared to second instar (86.66 and 56.68%) which implies that the later instar larvae were able to tolerate the toxic effect of insecticides.

The effect of pesticides on adults of *C. scelestes* is also furnished in Table 3. All pesticides except quinalphos, chlorpyriphos, malathion, dichlorvos and carbaryl were found to be totally safe during both exposure and 24 h post treatment period. The above toxic chemicals have produced 100% adult mortality within 6 h treatment period itself. Thus based on BARTLETT (1964) the level of toxicity of pesticides to eggs, larvae and adults of the predator *C. scelestes* was rated and presented in Table 4.

DISCUSSION

The pesticides tested in the present study had inflicted different degrees of mortality to various stage of *C. scelestes*. The eggs were totally unaffected by pesticides. Similar result

TABLE 4. Toxicity of pesticides to eggs, larvae and adults of *C. scelestes* based on rating.

Pesticides	Conc. %	Stage					
		E	N	I*l*	II*l*	III*l*	A
Endosulfan	0.07	O	O	O	O	O	O
Dicofol	0.05	O	O	O	O	O	O
Monocrotophos	0.05	O	H	O	O	O	O
Phosalone	0 05	O	O	O	O	O	O
Quinalphos	0.05	O	H	H	H	H	H
Chlorpyriphos	0.05	O	H	H	H	H	H
Methyldemeton	0.05	O	H	L	O	O	O
Phosphamedon	0.05	O	H	O	O	O	O
Malathion	0.10	O	H	H	H	M—H	H
Dimethoate	0.05	O	M	O	O	O	O
Dichlorvos	0.05	O	H	H	H	H	H
Carbaryl	0.10	O	H	H	M–H	L	H
Methomyl	0.05	O	H	H	O–M	O–L	O
Sulphur	0.16	O	O	O	O	O	O
Dithane	0.16	O	O	O	O	O	O

E = Eggs
N = Just hatched larvae
I*l* = First instar larvae
II*l* = Second instar larvae
III*l* = Third instar larvae
A = Adult

O = no kill
L = Low < 33.3% kill
M = Medium 33.3 to 66.7% kill
H = Highly > 66.7% kill

was also obtained by earlier workers like BARTLETT (1964) and KISMIR & SENGONCA (1980) with *C. carnea*. All three larval instars and adults were killed (70 to 100%) by insecticides like quinalphos, chlorpyriphos, malathion and dichlorvos. While monocrotophos, phosalone, methyldemeton, phosphamedon and dimethoate were found to be totally non-toxic to either larvae or adults in the present study. GORKAVENKO & SKORODUMOVA (1976) and BABRIKOVA (1980) have also reported that the chemicals such as phosalone and dimethoate were least toxic of the compounds tested for other species of chrysopids. BARTLETT (1964) also reported that of the organophosphates tested a few materials showed singularly low toxicity to *C. carnea*. Organochlorines, endosulfan and dicofol had little effect on egg stage of *C. scelestes* in the present study as earlier reported by PLAPP & BULL (1978) for *C. carnea*. Of the carbamates, carbaryl proved highly toxic to first instar larvae and adults but low to medium toxic to second and third instar larvae. Results of the above study is in conformity with that of LAWRANCE *et al.* (1973) LAWRANCE (1974) and LECRONE & SMILOWITZ (1980). Methomyl though produced low to high toxicity to larvae (PLAPP & BULL, 1978) completely innocuous to adults. The fungicides, sulphur and dithane were found totally innocuous to all the stages of *C. scelestes* and such results are in agrement with BARTLETT (1964) and BABRIKOVA (1980) who have studied with *C. carnea* and *C. formosa*. The present study clearly indicated that the predator *C. scelestes* had shown tolerance/resistance to several pesticides. Such relative tolerance/resistance of *C. scelestes* to several pesticides makes it suitable for use in integrated control programmes against pests of cotton, tobacco, vegetables, fruits etc.

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X-IRRADIATION- INDUCED HISTOCHEMICAL CHANGES IN THE OVARIES OF *DYSDERCUS KOENIGII* FABR.

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X-irradiation produces several histological and histochemical changes in the ovarian tissue of *D. koenigii* some of which could be regarded as pathological leading to cellular degeneration and others as precocious.

(Key words: X-irradiation, histochemical changes, ovaries, *Dysdercus*

INTRODUCTION

A large number of papers are available on the histochemical changes occurring in the ovaries of insects (see DESHPANDE & SRIVASTAVA, 1981 for references) but none to our knowledge on those induced by ionizing radiations in the telotrophic ovaries. In this paper we describe the effects of X-irradiation on the nucleic acids in some of the ovarian cells of *D. koenigii*.

MATERIALS AND METHODS

One day old 5th (ultimate) instar female nymphs of *D. koenigii*, obtained from our laboratory colonies, were exposed to a predetermined sterilizing dose of 2000 rad of soft X-rays by the procedure described by us earlier (SRIVASTAVA & DESHPANDE, 1983). The adults emerging from these nymphs were opened in insect Ringer (EPHRUSSI & BEADLE, 1936) at 5 day intervals up to 20 days postirradiation (p i) to obtain increasing effects and their ovaries fixed in Carnoy and Zenker, sectioned at 7.5 μm and stained in Feulgen for DNA and methyl green-pyronin G for both the nucleic acids as per PEARSE (1975).

RESULTS

Condition in normal ovaries

Germaria of the telotrophic ovaries of *D. koenigii* are divisible into terminal, middle and proximal zones. The terminal zone bears mononucleate trophocytes (MNT), the middle zone, both MNT and binucleate trophocytes (BNT) and trophic core and the proximal zone, the prefollicular cells (PFC) and oogonia (see DESHPANDE & SRIVASTAVA, 1981 for details). The chromatin of BNT nuclei undergoes condensation to form intensely Feulgen positive blobs (Fig. 1A), the like of which are not seen in their peripheral counterparts. In later stages, these BNT breakdown to release their blobs in the intercellular spaces from where they disappear (Fig. 1B). The nuclei of the oogonia are evenly but fairly DNA positive and their cytoplasm, RNA negative (Fig. 2). As the PFC surround an oogonium and the latter moves into the vitellarium as a follicle, the DNA positiveness of the nucleus declines and finally lost as it transforms into a germinal vesicle (Fig. 3). The nuclei of the follicular epithelial cells remain moderately DNA positive (Fig. 3).

Changes after X-irradiation

X-irradiation induces 2 changes in the ovarian cells: (1) blob fromation spreads to the peripheral BNT (Fig. 4)

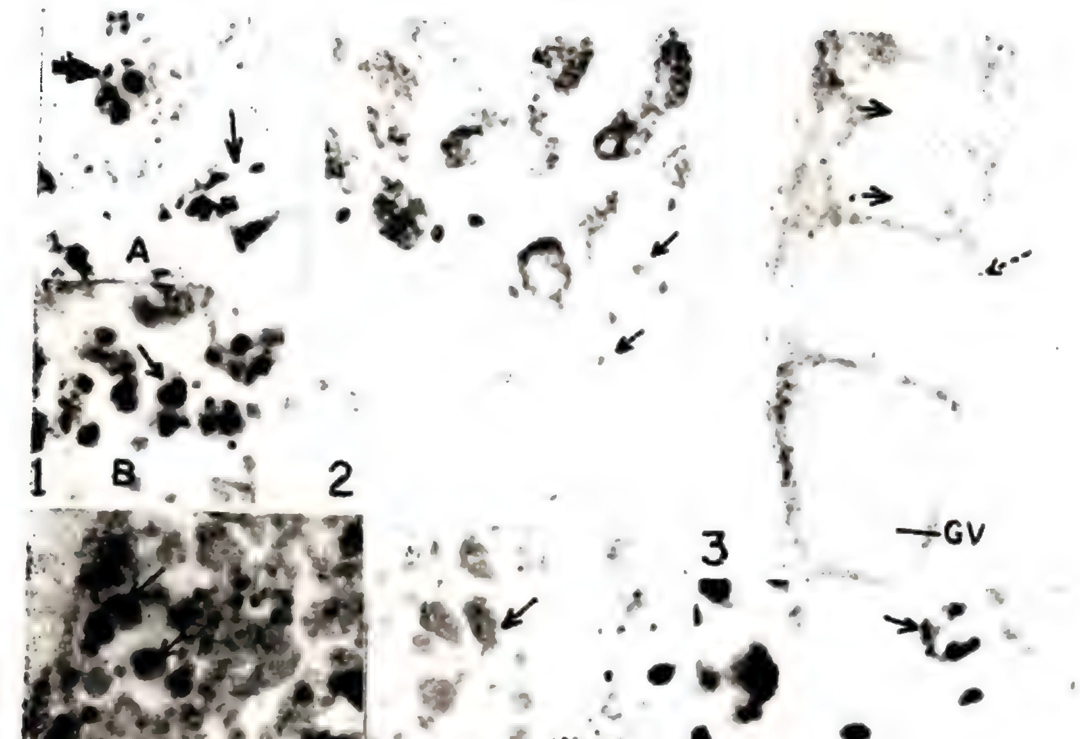
which in later stages show a distinct pyronin (RNA) positiveness both in the nucleus and cytoplasom (Fig. 5) instead of retaining their original methyl green (DNA) positiveness and (2) the oogonia undergo hypertrophy with their nuclei developing concentrated (strong) and diffused (faint) DNA positiveness. The nuclei with concentrated DNA may bear one or 2-3 closely set (Fig 6A) or separated (Fig. 6B) Feulgen positive bodies while those with diffused DNAshow a greatly reduced Feulgen postiveness (Fig. 7) similar to that occurring in the oocytes during transformation of their nuclei into germinal vesicle though not to the extent of losing all stainability as in the latter (cf. Fig. 3). Besides, the oogonial cytoplasm which is normally RNA negative (Fig. 2), turns pyronin (RNA) positive after X-irradiation (Fig. 8). The cells of the follicular epithelium in X-irradiated insects either hypertroppy or become hyperplasic (rapidly multiplying) with the nuclei in the former weakly DNA positive (Fig. 9) and in the latter strongly so (Fig. 10).

DISCUSSION

Condensation of chromatin in the form of DNA positive blobs in the BNT nuclei of *D. koenigii* was reported by us earlier (DESHPANDE & SRIVASTAVA, 1981). Since this feature first appears in the older BNT lying close to the trophic core, its occurrence in the peripheral BNT could be regarded as a precocity induced by X-irradiation. In regard to the change in the staining affinity of the BNT nuclei from methyl green to pyronin positiveness, it could just be a case of depolymerisation leading to configurational changes in the DNA molecule rather than an actual change in the chemical nature of the nucleic acid (see PEARSE, 1975, page 270). Enlargement of the oogonial cells by hypertrophy accompanied by a reduction in the DNA positiveness of their nuclei (diffused nuclei) could also be considered precocious since such changes are expected to occur in the oocytes and not in the oogonia. On the other hand concentrated nuclei with one, or more

EXPLANATION OF FIGURES

Fig. 1. Chromatin condensing to form DNA positive blobs in the normal BNT nuclei (A. arrow) with their subsequent breakdown to release the blobs (B. arrow). Feulgen, ×675; Fig. 2. Normal germarium showing oogonia with DNA positive nuclei (arrows)s urrounded by unstained (both DNA and RNA negative) cytoplasm. Methyl green-pyronin, × 450; Fig. 3. Normal oocyte nuclei showing declining DNA positiveness until complete unstainability in the germinal vesicle (GV). Note also the moderate DNA positiveness in the follicular epithelium nuclei (broken arrow). Feulgen, × 150; Fig. 4. Blob formation in (arrows) the peripheral BNT (10 days pi) methyl green-pyronin, × 315; Fig. 5. BNT nuclei showing pyronin (RNA) positiveness (arrow) and methyl green (DNA) positive nuclear residue (broken arrow) (15 days pi) Methyl green-pyronin, × 675; Fig 6. Hypertrophied oogonia showing concentrated nuclei with 1 or 2–3 closely set (A, arrows) or separated (B, arrow) DNA positive bodies (10 days pi). Feulgen, × 315; Fig. 7. Same showing diffused nuclei with reduced DNA positiveness (arrows) (10 days pi). Feulgen, × 450; Fig. 8. Same with RNA positive cytoplasm (arrow). Methyl green-pyronin, × 450; Fig. 9. Hypertrophied follicular epithelial cells showing weak DNA positiveness in their nuclei(arrows). (20 days pi) Feulgen, × 150; Fig. 10. Hyperplasic follicular epithelial cells showing a relatively stronger DNA positiveness in their nuclei (arrows). (20 days pi). Feulgen × 150.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closely set or separated DNA positive bodies are comparable to pycnosis, karayorrhexis and fragmentation respectively, already described by THEUNISSEN (1977) as pathological features that induce cellular degeneration.

Histochemical reactions in the cells of the follicular epithelium seem commensurate with the pathological symptoms induced by X-irradiation *viz.*, a weak DNA positiveness in the hypertrophied cells and a stronger one in the hyperplastic cells. Since hypertrophy of a cell is reportedly followed by nuclear degeneration (THEUNISSEN, 1977), a weak staining in the nuclei of the hypertrophied follicular epithelial cells may be simplay indicating nuclear degeneration. On the other hand, a stronger reaction to Feulgen in the hoperplasic cells tends to indicate an active DNA synthesis as expected in any rapidly multiplying cells.

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BRIEF COMMUNICATION

AN *IN VIVO* STUDY OF CARBOHYDRATE - DYE TRANSPORT THROUGH THE ALIMENTARY CANAL OF *SARCOPHAGA RUFICORNIS* (FABR.) (DIPTERA : SARCOPHAGIDAE)

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A mechanism for separating the bromophenol blue dye from the carbohydrates exists in the alimentary canal of *Sarcophaga ruficornis* when a mixture of these ingested materials passes through it. The operation of this mechanism leads to a differential migratory rate in the movement of carbohydrates and bromophenol blue during their transport through the mid- and hindgut regions of the digestive tract of this fly.

(Key words: carbohydrate and bromophenol blue transport, alimentary canal, *Sarcophaga ruficornis)*

Previous work on the transport of food through the digestive tract of insects is mostly based on the assumption that the movement of the dye used as a marker synchronises with that of the ingested food mixed with it (DAY & WATERHOUSE, 1953; HOUSE, 1974). However, KRISHNA & SINGH (1968), for the first time in insects, demonstrated in the workers of termite *Odontotermes obesus* (Rambur) that the rates of passage of certain sugars and bromophenol blue dye through their alimentary canal varied with the type of sugar mixed with the dye. The monosaccharides moved into the midgut independent of and earlier than the dye. But the oligosaccharides, although they travelled faster than the dye from mid- to hindgut, always moved along with the dye from fore- to midgut. In the light of this background knowledge and based on a recent account of ROHATGI (1984) mentioning a relatively faster mobility of bromophenol blue-mixed sucrose through the midgut of males than of females of the fleshfly, *Sarcophaga ruficornis*, we considered it desirable to examine the carbohydrate-dye transport rate in the alimentary canal of these flies fed on certain poly-, oligo- or monosaccharides. Our findings concerning this study are reported in this communication.

Male and female individuals, obtained from a laboratory stock culture (SINGH & CHAND, 1981), were separated on emergence and fed individually for the first 6 days on a solution of condensed milk provided through a hanging glass tube inside glass jars. They were then starved for 24 hours before allowing them to ingest for 5 minutes one of 5 selected carbohydrate solutions (starch, raffinose, sucrose, fructose and arabinose) mixed with

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bromophenol blue dye in the ratio of 5:0.01 (w/w). Five minutes after food intake, each fly was dissected under a binocular microscope to expose its alimentary canal. Presence of the dye inside the gut, besides confirming ingestion of the test carbohydrate by the insect, also indicated the exact position up to which the dye had travelled through the gut during the 10-minute period. Presence or absence of the ingested carbohydrate in the different parts of the gut of 5 fed specimens for each sex was biochemically determined by paper partition chromatography of the gut contents (KRISHNA, 1958). All experiments were carried out at $29 \pm 1°C$ and RH $85 \pm 5\%$.

Whithin 10 minutes of feeding, the ingested food, in both male and female flies, reached the hindgut with or without the dye whose movement through the mid- and hindgut portions, however, varied with the type of carbohydrate with which it was mixed (Fig. 1). The monosaccharides and the dye travelled together up to the proximal loop and helicoid divisions of the midgut in females and males respectively. Beyond these parts, the monosaccharides always moved through the gut independent of and earlier than the dye. The transport of oligosaccharides, although it synchronised with that of dye within fore- and midgut, was relatively faster from mid- to hindgut in both sexes and in females this differential movement commenced from the middle of the helicoid region of the midgut itself. The polysaccharide starch, on the other hand, accompanied the dye all along its movement through the alimentary canal up to the hindgut where the carbohydrate overtook the dye during the final lap of its journey from the rectal pouch in males and from the first part of the rectum in females.

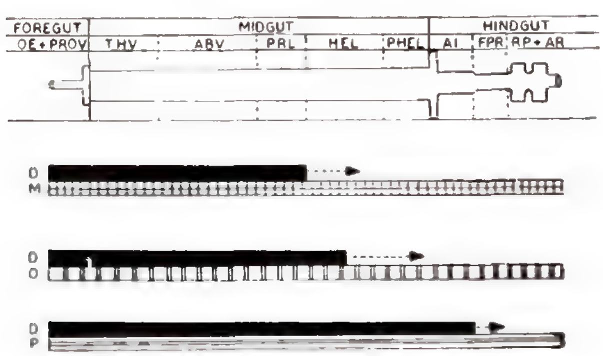

Fig. 1. Diagrammatic representation of the differential movement of carbohydrates and bromophenol blue dye within the gut of male/female adult individuals of *S. ruficornis*.

ABV—Abdominal ventriculus; AI—Anterior intestine; AR—Anal rectum; D—Bromophenol blue dye; FPR—First part of rectum; HEL—Helicoid region; M—Monosaccharides; O—Oligosaccharides; OE—Oesophagus; P—Polysaccharide; PHEL—Post helicoid region; PRL—Proximal loop; PROV—Proventriculus; RP—Rectal pouch; THV—Thoracic ventriculus.

Broken arrow length indicated inside each top horizontal bar of a pair denotes the extent to which the dye migrates, in relation to the carbohydrate mixed with it, inside the gut of male flies.

On the basis of these observations we suggest that the gut of *S. ruficornis* is endowed with a mechanism capable of efficiently segregating the carbohydrate from the dye blended in the ingested diet, a feature similar to that recorded till now only in termite *(Odontotermes obesus)* workers in insects (KRISHNA & SINGH, 1968). The operation of this mechanism progressively shifts backwards in the gut with increased complexity in the chemical character of the carbohydrate mixed with the dye. This, in turn, results in an overall interesting differential pattern in the movement of the dye and the saccharides through the digestive tract of this fly.

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LOW TEMPERATURE STORAGE OF ADULTS OF *BRACON BREVICORNIS* WESMAEL (HYMENOPTERA: BRACONIDAE)

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Low temperature storage studies were carried out at 5°C and 50—60% R H with *Bracon brevicornis* Wesmael an important indigenous parasite used for inundative releases against *Opisina arenosella* Wlk., a serious pest of coconut in India. Two day old adults of *B brevicornis* stored for 30, 60 and 90 days gave 12.40%, 47.37% and 54.66% mortalities. Males were more susceptible when compared to females. With increase in the duration of storage, reduction in fecundity and longevity was observed and sex ratio was also found to be altered in favour of males.

(Key words: low temperature storage, *Bracon brevicornis, Opisina arenosella*, Cocount)

INTRODUCTION

Opisina arenosella Wlk. is a serious pest of coconut in Andhra Pradesh, Bihar, Goa, Karnataka, Kerala, Maharashtra, Orissa, Tamil Nadu and West Bengal in India (MOHAMED, 1982). It is also reported from Gujarat (ANJARIA *et al.*, 1976). Biological control by inundative releases of indigenous natural enemies has been the main tool in the fight against this pest during the past six decades (RAO *et al.*, 1948) and the gregarious ectoparasite *Bracon brevicornis* Wesmael is one of the parasites widely used for this purpose (RAO *et al*, 1971, MOHAMED, 1982). *O arenosella* is present throughout the year but appears as a serious pest only during the hot months (MENON & PANDALAI, 1958). The presence of distinct broods makes it imperative for the laboratories employed in mass multiplication to accumulate enough parasite material so that adequate numbers can be released at required times. Development of suitable storage techniques helps in accomplishing this goal.

Preliminary studies indicated that newly emerged adults are more tolerant to storage at low temperatures. The present study was conducted to determine the maximum period for which the adults of *B. brevicornis* can be stored and also the effect of storage on fecundity and longevity of stored adults and on the sex ratio of their progeny.

MATERIALS AND METHODS

B. brevicornis was reared in the laboratory on larvae of *Corcyra cephalonica* (Staint.). Cocoons were collected and placed in glass chimneys for adult emergence. Emerging adults were collected at the rate of a minimum number of ten in 15 × 2.5 cm glass vials and plugged with cloth covered cotton wool. For feeding the adults 50% honey was provided inside on cotton swabs. After giving sufficient time for the adults to mate and feed for 2 days these vials were held directly in a BOD

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incubator set at 5 ± 1°C and relative humidity between 50—60%. The vials with adults were then taken out periodically at 10 day intervals from the 10th to the 90th day. A minimum number of 10 vials were taken out at a time as replicates of one treatment for computation of per cent mortality in each sex of *B. brevicornis*.

Ten pairs of surviving adults were collected out from the vials taken out after 30, 60 and 90 days of storage and released in separate chimneys. Fecundity was calculated by exposing ten larvae of *C. cephalonica* at 2 day intervals and female mortalities were also recorded. The total number of progeny produced by females subjected to 30, 60 and 90 days of storage was observed and the sex ratios in the progeny were calculated. These observations were compared with those of unstored adults. The laboratory temperature and humidity during these studies were 26 ± 2°C and 60—80% respectively.

RESULTS AND DISCUSSION

The per cent mortalities of adults after storage for different durations are presented in Table 1. Storage of adults upto 10 days did not cause any mortality. The mortality was found to increase with the increase in the duration of storage. However, males were found to be more susceptible to low temperature when compared to females.

The data on longevity, fecundity and sex ratio of the progeny of the stored adults of *B. brevicornis* are furnished in Table 2. Females stored for 0, 30, 60 and 90 days survived for 38.9 27.6, 25.7 and 19.6 days and produced 171.6, 93.3, 68.2 and 21.1 progeny. Longevity of adults was found to decrease with the increase in the duration of storage at low temperature. Similarly the fecundity of stored females was also reduced to 21.1 progeny in 90 days duration as against 171.6 progeny in no storage.

Stored females produced both female and male progeny. However, the sex ratio was found to be altered in favour of males with an increase in the duration of storage (Table 2). DEBACH & RAO

TABLE 1. Mortality of *B. brevicornis* adults after storage at 5 ± 1°C for different durations.

Period of storage (in days)	No. of adults stored			% mortality		
	♀	♂	Total	♀	♂	Total
10	56	49	105	0	0	0
20	72	49	121	4.17	8.16	5.79
30	76	53	129	6.58	20.75	12.40
40	115	95	210	8.70	25.26	16.19
50	96	61	157	7.30	27.86	15.29
60	83	88	171	27.71	65.90	47.37
70	81	81	162	33.33	74.07	53.70
80	75	80	155	38.67	68.75	54.19
90	134	102	236	38.05	76.47	54.66

Table 2. Longevity, fecundity and sex ratio of the progeny of stored adults of *B. brevicornis*.

Period of storage (days)	Longevity of females (days)	Fecundity	Sex ratio (♂ : ♀)
0	38.90 ± 8.92	171.60	1 : 0.85
30	27.60 ± 9.45	93.30	1 : 0.56
60	25.70 ± 9.00	68.20	1 : 0 39
90	19.60 ± 5.50	21 10	1 : 0 30

(1968) had reported that exposure of *Aphytis lingnanensis* compared to the low temperature of 30°F (—1°C) for 8 hours or more nearly always caused 100% mortality of sperm in the testes of males and in the spermathecae of mated females.

This study has shown that storage of *B. brevicornis* up to 30 days did not cause much mortality and also did not greatly reduce fecundity and percentage of female progeny. This finding can therefore be used for storing large numbers of parasites for the inundative field release programme on coconut against *O. arenosella*. As this method does not involve acclimatization before or after storage (ARCHER *et al.*, 1973) and removal and feeding while being stored (ARCHER & EIKENBARY, 1973) it can easily be adapted by the parasite breeding laboratories.

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MASS REARING TECHNIQUE FOR A MEXICAN PARASITE, *ALLORHOGAS* SP. (HYMENOPTERA : BRACONIDAE) INTRODUCED FOR TRIALS AGAINST GRAMINACEOUS BORERS IN INDIA

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Allorhogas sp. a gregarious ectoparasite was introduced for trials against graminaceous stem borers in India and a mass rearing technique developed for rhe same. The rearing cage was a modified 20×16 cm clear plastic jar and *Chilo partellus* (Swinh.) larvae were exposed for parasitisation inside drinking paper straws. By releasing 84 females into the cage it was possible to rear 1229 cocoons in 5 exposures of 28 larvae each within 10 days. *Allorhogas* sp. was also found capable of parasitising *C. auricilius* (Dudg.), *C. infuscatellus* Snell, *C. sacchariphagus indicus* Kapur, *Acigona steniella* (Hamps.), *Scirpophaga incertulas* (Wlk.) *Sesamia inferens* (Wlk.) and *Corcyra cephalonica* (Staint.)

(*Key words: Allorhogas* sp., paddy, sugarcane)

INTRODUCTION

Lepidopterous stem borers are serious pests of graminaceous crops like paddy, sugarcane etc., in India. Indigenous parasites are not capable of keeping these pests under check. RAO & NAGARKATTI (1971) have also reported the ineffectiveness of local parasites against sugarcane borers. Under the All India Co-ordinated Research Project on Biological Control of Crop Pests and Weeds, *Allorhogas* sp. (Hym. : Braconidae) a gregarious ectoparasite of *Eoreuma (Acigona) loftini* (Dyer) was introduced from Mexico in 1982.

Larvae of *Chilo partellus* (Swinh.) reared on an artificial diet developed by REDDY & DAVIES (1978) were exposed to the parasite by releasing inside paddy stems. As this process was found to be tedious and since large numbers cannot be multiplied by following this method a mass multiplication cage was developed which is described in this paper. The parasite was also tested against various graminaceous stem borers under laboratory conditions to find out suitable hosts which in turn will help in carrying out further field studies.

MATERIALS AND METHODS

Fecundity and longevity:

For this study five pairs of newly emerged adults were first collected into separate jars. From the 3rd day after emergence 2 larvae of *C. partellus* were exposed to each female on alternate days. This process was repeated until all the females died. The cocoons produced by each female were collected out and sex ratio of the emerging adults was determined.

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Mass rearing method:

The basic rearing unit consisted of a 20 × 16 cm clear plastic jar (Fig. 1). Twenty eight holes of 4 mm dia. were neatly punched with a heated cork borer all along the periphery of the lid. A 35 mm hole was made at the centre of the lid and a screw cap plastic container, the bottom of which was cut, was fixed and heat sealed. At the inner surface of the lid, below the hole a 10mm thick sponge of 60 mm dia. was fixed. This sponge, when moistened with 50% honey, served as a source of food to the adults. A similar screw cap vial fixed on the side of the jar served as the opening for introducing parasites inside the cage. Two 100 mm circular windows were cut out on the sides of the plastic jar and brass wire mesh (80 mesh) was fixed for ventilation. A circular piece of sponge was cut to fit at the bottom of the cage and was moistened to provide humidity. The lid was then placed over the jar and sealed with surgical tape.

Full grown larvae of *C. partellus* were released inside 28 drinking paper straws and both ends were plugged with cotton, which was pushed well inside. The prepared straws were introduced through the holes on the lid and 84 mated females (based on preliminary studies) released inside the cage. The exposed straws were replaced with fresh straws with larvae on alternate days and a total of ten sets of straws were exposed to the same females.

Host range studies:

For testing the host range, larvae of different graminaceous borers collected from the field were released inside the paper straws and exposed to the parasite. The suitability of these larvae for parasite development was then observed.

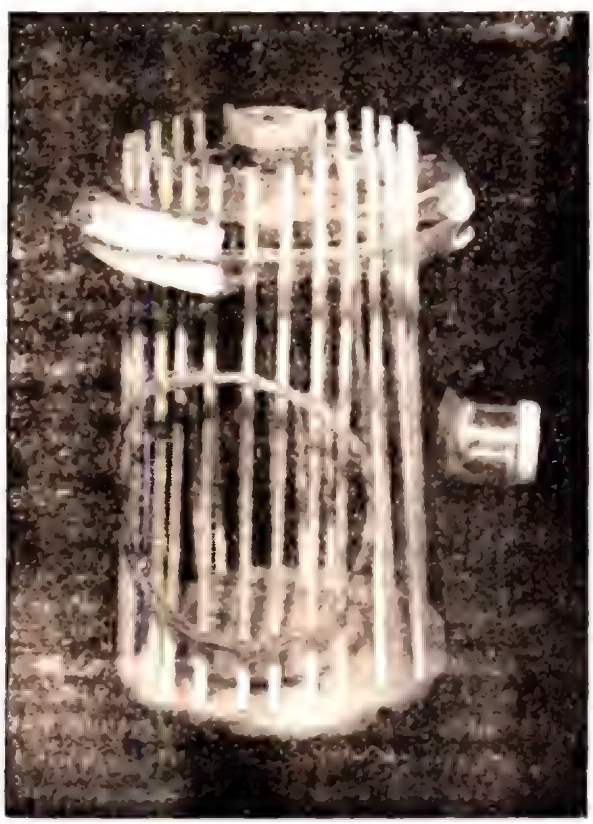

Fig. 1. Rearing unit of *Allorhogas* sp.

The studies were conducted at laboratory room temperature of 26 ± 2°C and 50–60% RH.

RESULTS AND DISCUSSION

Females of *Allorhogas* sp. mated soon after emergence and were ready for oviposition 2 days later. They were able to detect the presence of larvae inside paddy stems and paper straws. The larvae were paralysed by insertion of ovipositor right through the stem/straw and eggs were also laid in the same manner. The total developmental period was observed to last 20—22 days. One to twelve cocoons were collected per larva. Adult females lived for 33 ± 14.5 days producing 35.2 ± 14.7 cocoons and the sex ratio was found to be 1:3.4 (male : female). However, it was observed that 74.4% of the total progeny were produced in the first 3 exposures with the subsequent 3 exposures producing a further 9.4%.

The results of the studies on exposing 28 *C. partellus* larvae inside paper straws on alternate days to *Allorhogas* sp. at 1:3 ratio is given in Table 1. In the first exposure 89.29% of the larvae were parasitised and the average number of cocoons collected per exposed larva was 10.07. In the first 5 exposures more than 50% of the larvae were found to be parasitised and the average number of cocoons collected per exposed larva also remained above 7. A sharp decline in parasitisation and cocoon production was observed from the 6th exposure. The first 5 exposures produced 1229 cocoons over a period of 10 days with more than 200 cocoons per exposure. As further exposures lead to wastage of larvae it is desirable to restrict exposures to 5 with each batch of adults. It is possible to increase the productivity of the cage by exposing two larvae per straw after making comparments with cotton inside and releasing more adults into each cage.

TABLE 1. Productivity of mass multiplication cage for rearing *Allorhogas* sp.

Exposure No.	No. of larvae exposed	% parasitism	No. of cocoons produced	No. of cocoons per larvae exposed
1	28	89 29	282	10.07
2	28	92.86	261	9.32
3	28	67.87	241	8.60
4	28	78.57	242	8.64
5	28	53.57	203	7.25
6	28	42.86	94	3.36
7	28	35.71	84	3.00
8	28	14.29	64	2 29
9	28	7.14	20	0.71
10	28	7.14	14	0.50

Host range studies showed that *C. auricilius* (Dudg.), *C. infuscatellus* Snell., *C. sacchariphagus indicus* Kapur, *Acigona steniella* (Hamps) *Scirpophaga incertulas* (Wlk.) and *Sesamia inference* (Wlk.) which are important pests of graminaceous crops in India were readily accepted for parasitisation. Hence *Allorhogas* sp. can be used for releases against the above pests under field conditions. The parasite is reported to have been recovered from the field in Lucknow from *C. auricilius* (ANON., 1983). Release of *Allorhogas* sp. may also be useful in controlling the above pests attacking wild grasses, which are more accessible to the parasites (NAGARKATTI & NAIR, 1973).

It was observed that *Allorhogas* sp. can parasitise larvae of *Corcyra cephalonica* (Staint.) introduced inside paper straws with a few broken grains of jowar.

Even though percentage parasitism was observed to be low it can be used as an alternative laboratory host at times when *C. partellus* larvae are not available.

Acknowledgements: The authors are grateful to Dr. F. D. BENNETT, Director, Commonwealth Institute of Biological Control for arranging shipment of the parasite and to Dr. K. L. CHADHA, Direcror, Indian Institute of Horticnltural Research, Bangalore for facilities provided. The assistanee provided by Mr. S. K. JALALI, Technical Assistant (T—4) is gratefully acknowledged.

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BRIEF COMMUNICATION

EFFECT OF SOME INSECTICIDES ON THE EMERGENCE OF THE PARASITOID, *TRICHOGRAMMA CHILONIS* ISHI (HYMENOPTERA : TRICHOGRAMMATIDAE)

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Laboratory experiment was conducted to find out the effect of four insecticides in two doses each on the emergence of *T. chilonis* on *E. vittella* eggs. When endosulfan, monocrotophos and phosalone were sprayed on parasitised eggs, the emergence of adult parasitoids was not affected very much.

(Key words: Trichogramma chilonis, egg-parasitoid, cotton, *Earias vittella*, insecticides)

Trichogramma chilonis Ishi is an effective parasitoid of *Earias vittella* Fab. infesting cotton. Indiscriminate use of insecticides on cotton causes great harm to this parasitoid. Not much work on the effect of insecticides on egg parasitoids has been done except by NAVARAJAN PAUL *et al.* (1979) who studied the effect of some insecticides on the parasitization and emergence of *Trichogramma braziliensis* (Ashmead) on *Corcyra cephalonica* St. eggs. Present laboratory experiment was therefore, planned to find out the effect of commonly used insecticides for the control of bollworms on the emergence of the egg parasitoid, *Trichogramma chilonis* Ishi from *Earias vittella* Fab. eggs.

Monocrotophos (Nuvacron), endosulfan (Thiodan), phosalone (Zolone) and carbaryl (Sevin) were tested at the recommended field doses and at half of their doses. Fresh eggs of *E vittella* laid on a muslin cloth were exposed to one-day old mated females of *T. chilonis* at 1:5 (parasitoid/host) for 6 h and then sprayed with insecticides to the level of wetting them using a chromatography sprayer. The egg cloths were allowed to dry in shade. Another set of eggs were sprayed with insecticides, shade-dried and then exposed to parasitoids in a similar manner. Both sets of eggs were kept in a 500 ml capacity plastic container covered with muslin cloth for parasitoid emergence. The number of eggs per treatment ranged from 95—125 and three replications were run. Adult parasitoids emerged after ten days were recorded and percentage of emergence was worked out for statistical analysis.

The results summarised in Table 1 indicate that the differences between the insecticides and concentrations were highly significant. The parasitoid emergence was drastically reduced ranging from 2 09 to 24 08 per cent as compared to 69.11 per cent in control when host eggs were treated with insecticides before parasitization but when parasitized eggs were exposed to insecticides, the reduction

TABLE 1. Effect of insecticides on the emergence of the parasitoid *Trichogramma chilonis*.

Treatments	Parasitoid emerence (per cent)	
	Sprayed and exposed	Exposed and sprayed
Monocrotophos 0.05%	11.06 (19.39)	31.42 (34.08)
Monocrotophos 0.025%	24.08 (29.32)	67.90 (55.51)
Endosulfan 0.07%	2.09 (8.23)	48.31 (44.04)
Endosulfan 0.035%	9.83 (18.24)	70.90 (57.37)
Phosalone 0.1%	13.26 (21.30)	34.01 (35.66)
Phosalone 0.05%	23.96 (29.31)	46.45 (42.98)
Carbaryl 0.1%	3.99 (11.40)	10.30 (18.68)
Carbaryl 0.05%	8.22 (16.61)	13.48 (21.52)
Untreated	69.11 (56.31)	71.26 (57.64)
S E	(0.906)**	(0.791)**
C D (P : 0.05)	(2.72)	(2.37)

Values in parentheses are Arcsine $\sqrt{\text{percentage}}$.
** Significant at 1% level.

in emergence was not that pronounced. Whether treated and exposed or exposed and treated, the higher concentrations of all insecticides were more detrimental than the lower dosages. Carbaryl 0.1 and 0.05% recorded the minimum emergence (10.30 and 13.48 per cent respectively) from exposed and sprayed eggs in comparison to other treatments. Endosulfan (0.035%) and monocrotophos (0.025%) when sprayed on parasitised eggs resulted in significantly similar parasite emergence to that of control. The lower emergence of parasitoids when the host eggs were treated before parasitization may be due to reduced oviposition because of repellency of the insecticides.

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ESTIMATION OF DAMAGE CAUSED TO *CHROMATOMYIA HORTICOLA* POPULATION ON *BRASSICA CAMPESTRIS* BY HYMENOPTERAN PARASITES

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The larval parasites of *Chromatomyia horticola* (Gour.) killed about 65.80—86.60% of pest population during immature stages. The remaining larval population, which succeeds in reaching the pupal stage, is further depleted to the tune of 50.00—56.00% on *Brassica campestris* L. This clearly establishes that the Hymenopteran parasites exert a pronounced influence in maintaining equilibrium in the *Chromatomyia horticola* population.

(Key words: damage, *Chromatomyia horticola* population, Hymenopteran parasites)

INTRODUCTION

The polyphagous species *Chromatomyia horticola* is the most common leaf-miner in India and does severe damage to *Pisum sativum* and *Brassica campestris* besides other important crops. The Hymenopteran parasites of this fly play important role as natural biotic limiting factor against the growth of pest population. During the course of present investigations eight Hymenopteran parasites belonging to three categories viz., larval, larval-pupal and pupal were reared. Out of the eight parasites only five parasites viz., *Chrosonotomyia formosa* Westw., *Diglyphus isaea* (Walk.) (larval), *Opius turcicus* Fischer, *Opius exiguus* Wesm, (larval pupal) and *Sphegigaster* sp. (pupal) constitute the dominant component of the parasite complex while the remaining three viz., *Tetrastichus* sp., *Eulophus* sp. and *Pediobius acantha* (Walk.) represent a relatively minor and insignificant element as the parasitization caused by them is almost negligible.

MATERIALS AND METHODS

The material for the present study was collected from the cultivated fields of *Brassica campestris* in and around Agra and from the experimental plot attached to the school of Entomology, St. John's College, Agra. The infested leaves collected randomly from the fields were examined under binocular microscope and larvae and pupae were separated by cutting small portions of the leaves and put them after counting in separate glass tubes whose mouths were plugged with cotton. The larval and pupal stocks of *Chromatomyia horticola* in glass tubes were kept in the rearing cabinet maintained at 30 ± 2°C and 70% R H. The percentage of parasitism was calculated on the basis of emergence of parasites out of the total number of the larvae and pupae contained in the given tube.

RESULTS AND DISCUSSION

The data concerning the loss of larval population of *Chromatomyia horticola* on *Brassica campestris*, by the combined influence of all the larval parasites, for the year 1979-1980, 1980-1981, and 1981-1982, at Agra, are presented in Fig. 1. A careful study of the Fig. would show the efficacy of larval

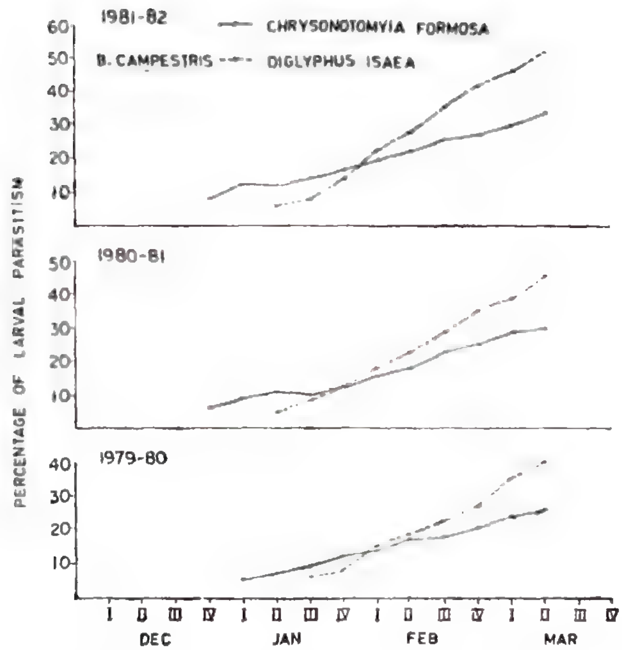

Fig. 1. Percentage of larval parasitism in *C. formosa* and *D. isaea.*

parasites in minimizing the pest population. In the initial stages of the crop, when the pest starts appearing some time in the end of December and in the beginning of January, the extent of damage to the larvae by the Hymenopteran parasites is rather negligible. The high percentage of damage to the larvae, however, is attained only near the harvesting time of the crop. During all the years under study starting from the end of December to the harvesting time by the middle of March there is a steady increase in the incidence of total larval parasitism from 5.00% to 65.80% in 1979-1980; 6.30% to 75.50% in 1980-1981 and from 8.30% to 86.60% in 1981-1982.

As evidenced by the details given above a farily large segment of the larval population of the pest is taken care of by different Hymenopteran parasites. It is, therefore, clear that the natural biotic limiting factors are operative even against larval stages and thus exercise a profound influence against the growth of *Chromatomyia horticola* population.

The larval stages of the *Chromatomyia horticola* which escape mortality are, however, not completely free from the ill effects of parasitism. Though these larvae succeed in pupating, a considerable proportion is not allowed to emerge as imagines of *Chromatomyia horticola* by the larval-pupal parasites *Opius turcicus* and *Opius exiguus*, who themselves pupate within the puparia of the host. Besides these two larval-pupal parasites the other purely pupal parasite i. e., *Sphegigaster* sp. further depletes the population of pupal stages of the pest.

This obviously means that the larval population of the pest which escape the adverse effects of the larval parasites are not rendered immune to the depredatory influences of pupal parasites. As is shown in Figs. 2, 3 and 4, the pupal parasites of *Chromatomyia horticola*, on *Brassica campestris*, play havoc with the pupal st. ges of the pest. A careful study of the Fig. would reveal that the pupal parasites appear some time in the second or third week of December and attack the pupae of the first generation of pest. With the steady growth of pest population in the fields the pupal parasites also exhibit a gradual and the leaf-miner infestatin was completely checked. KAURAVA *et al.* (1969) reported that *Neochrysocharis* sp. accounted for 80% larval parasitism and *Opius* sp. caused 40% pupal parasitism to *Phytomyza atricornis* Meigen. Recently MC CLANAHAN (1975, 1977, 1980) made attempts to control the *Liriomyza sativae* Blanch. with *Diglyphus begini* (Ashm.) and *Opius dimidiatus* (Ashm.). ZUCCHI & LENTERN (1978), HENDRIKSE & ZUCCHI (1979) HENDRIKSE (1980) tried to control *Liriomyza bryoniae* with *Dacnusa sibirica* and *Opius pallipes*. These studies indicated that the Hymenopteran parasites can afford good control of the leaf-miners.

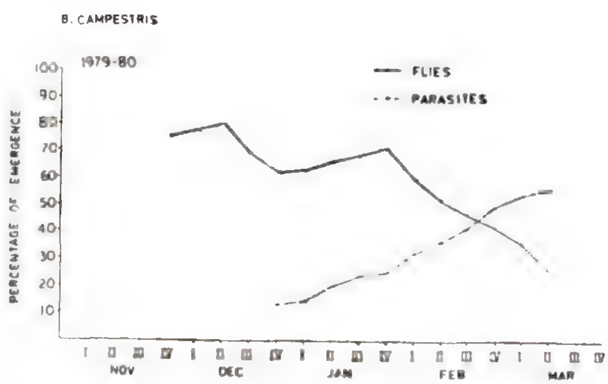

Fig. 2. Percentage of emergence in *B. campestris* in 1979–1980.

and consistent increase in their number. For instance on *Brassica campestris* the percentage of pupae destroyed by pupal parasites increase from 13.30% in December to 56.60% in March during 1979-1980; from 11.00% to 52.30% during 1980-1981 and from 9.00% to 50.00% during 1981-1982.

KELSEY (1937) reported that at the completion of third generation of *Phytomyza atricornis* Meigen, 100% of the fly puparia contained parasites

In the light of the above discussion, and the existance of three categories of parasites i e., larval, larval-pupal and pupal, and their seasonal succession demonstrates that the population of *Chromatomyia hortitola* during all its developmental stages is never allowed to be free from the pressure of biotic limiting factors. As evidenced by the Figs. referred above about 65.60-86.60% of the larvae, representing a potential population of the *Chromatomyia horticola*

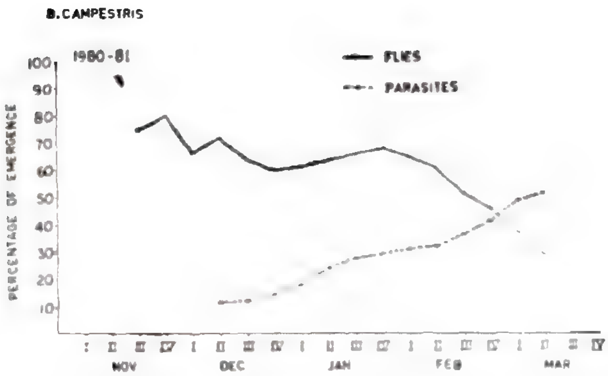

Fig. 3. Percentage of emergence in *B. campestris* in 1980-1981.

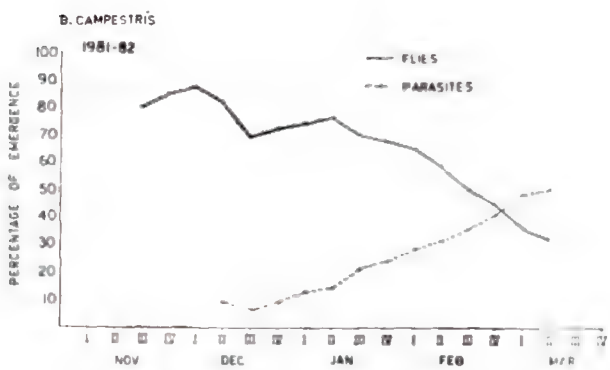

Fig. 4. Percentage of emergence in *B. campestris* in 1981-1982.

in the succeeding year, are destroyed by the combined efforts of the Hymenopteran parasites. The remaining larval population, which succeeds in reaching the pupal stage, is further depleted to the tune of 50.00-56.60% on *Brassica campestris*. It, therefore, establishes that the Hymenopteran parasites exert a pronounced influence in maintaing equilibrium in the *Chromatomyia horticola* population, though the dynamics of this equilibrium is not yet properly understood. It would, therefore, appear to be ideal if this aspect of pest-parasite interaction is further investigated with a view to evolving a strategy for the pest management programme.

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INCIDENCE OF PARASITISM OF *DIGLYPHUS ISAEA* (WALK.) ON *CHROMATOMYIA HORTICOLA* (GOUR.) A PEST OF *PISUM SATIVUM* IN NORTHERN INDIA

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An analysis of the incidence of parasitism of *Chromatomyia horticola* by *Diglyphus isaea*, makes it clear that the rate of parasitism, on *Pisum sativum* is conspicuously higher in the sub-humid zone as compared to semi-arid region. The semi-arid conditions of western Uttar Pradesh appear to be detrimental to the growth of parasite population build up, thus giving greater chance for the pest population build up. On the other hand in the humid mountainous regions, the incidence of parasitism near the harvesting time is generally lower as compared to the semi-arid and sub-humid zones.

(Key words: parasite, *Diglyphus isaea, Chromatomyia horticola*, pest, *pisum sativum*, Northern India)

INTRODUCTION

The pea leaf-miner, *Chromatomyia horticola* is probably the most common and destructive leaf-miner in India. Damage is caused by the mining activities of the larvae within the leaf tissues and by the feeding and oviposition habits of the female. In severe cases of infestation a single leaf of *Pisum sativum* may harbour more than fifty larvae resulting in complete withering of the leaf.

The leaf miner is reduced to relatively low numbers under natural field conditions by various Hymenopteran parasites. In India, the significance of parasites as natural checks on the Agromyzid pest population has been largely overlooked because of the progressive use of pesticides and insecticides as an easy method of control and our knowledge on the ecology of their Hymenopteran parasites is practically non-existent. Therefore, with a view to understanding the impact of Hymenopteran parasites on the *Chromatomyia horticola* population, the present investigations were initiated. The present paper contains the results of field investigations on the larval parasitism of *Chromatomyia horticola* (Agromyzidae : Diptera) caused by *Diglyphus isaea* (Eulophidae : Hymenoptera) on *Pisum sativum* in different climatic zones of Uttar Pradesh.

MATERIALS AND METHODS

The study was carried out by dividing the state into three natural climatic zones viz., (i) Semi-arid zone with less than 100 cm annual rain-fall; (ii) Sub-humid zone with rainfall varying between 100 and 140 cm; and (iii) Humid zone with rainfall more than 140 cm (TIWARI, 1971). The stations in the semi-arid zone were Agra, Mathura and Etawah while the stations of the sub-humid zone were Gorakhpur, Jaunpur and Allahabad. In the humid zone mountainous areas of Himachal Pradesh were selected due to the

extensive cultivation of peas as cash crops. This crop is not as extensively grown in the mountainous regions of Uttar Pradesh, hence the selection of Himachal Pradesh region for these investigations.

Hymenopteran parasites were reared from the field collected parasitized larvae of *Chromatomyia horticola* in the rearing cabinet maintained at 30±2°C, 70% R H. The immature stages and the adult parasites were preserved in the Pample's fluid. Commercial mountant polyglyce was used for mounting parts of the parasites.

RESULTS AND DISCUSSION

A study of the data on the parasitism caused by *Diglyphus isaea*, as given in Table 1 reveals that greater portion of *Chromatomyia horticola* population infesting *Pisum sativum* is killed in the sub-humid zone than in the semi-arid zone. The highest incidence of parasitism by this parasite in the semi-arid zone is 16 35% in February at Agra, 48.0% in March at Etawah and 26.08% in February at Mathura. The figures for the corresponding period in the sub-humid zone are 28.53% at Gorakhpur, 55.88% at Jaunpur and 48.66% at Allahabad. LAL & NAJI (1979) recorded that *Diglyphus isaea* parasitise 20.0—25.0% larvae of *Phytomyza horticola (= Chromatomyia horticola)*. IBRAHIM & MADGE (1979) reported that *Diglyphus isaea* is the dominant larval parasite of the parasite-complex of *Phytomyza syngenesiae* and caused about 40.0% larval mortality. KAURAVA *et al.* (1969) reported that parasitism in the larvae of this fly on pea crop increased from 2.0 to 84.0% by the end of the season.

Reference to the Table 2 giving the data of larval parasitism on *Pisum sativum* in the humid mountainous region would show that incidence of larval parasitism near the harvesting time is generally lower as compared to semi-arid and sub-humid zones. The lower rate of parasitism in the humid zone can probably be attributed to the differing crop growing periods, and over all low temperatures in the mountains with relatively high humidity. The crop growing period in the plains of Uttar Pradesh extends from November to March whereas in the mountainous regions it stretches from April to June.

An analysis of incidence of parasitism in different parts of Uttar Pradesh would make it abundantly clear that the rate of parasitism is conspicuously higher in the sub-humid zone as compared to the semi-arid region. The semi-arid conditions of the western Uttar Pradesh appear to be detrimental to the growth of parasite populations, thus giving a greater chance for the pest population build up. The vulnerability of Hymenopteran parasites to the arid conditions has also been pointed out by SINGH (1982) while discussing the impact of climatic conditions on the growth of parasite population. PRADHAN (1964) while discussing the insect populations also referred to the outbreak of pest populations, following drought conditions which brought about higher mortality among the parasites as compared to the pests.

It is clear from the above description that in the semi-arid zone stations where average maximum temperature varies from 22.3 to 28.0°C with 59.5—66.0% average relative humidity, the incidence of parasitism is lower as compared to sub-humid zone. On the other hand in the sub-humid zone with average maximum temperature range being almost idential (21.5 –26.5°C) to the semi-arid zone comparatively high relative humidity

TABLE 1. Table showing the larval parasitism of *Chromatomyia horticola* on *Pisum sativum* in semi-arid and sub-humid zones of Uttar Pradesh during the years 1979—1980, 1980—1981 and 1981—1982.

Rainfall......Below 100 cm Average Max. temp.......22.3 — 28.0°C Average R H..........59.5 — 66.0% Semi-arid zone					Rainfall..........100 — 140 cm... Average Max. temp.........21.5 — 26.5°C .. Average R H...........65.5 — 70.2% .. Sub-humid zone	
Year	Month	Week	No. of larvae	Larvae parasitized by *D. isaea* No. / %	No. of larvae	Larvae parasitized by *D. isaea* No. / %
		AGRA			GORAKHPUR	
1979—1980	Dec.	III	56	—	72	—
	,,	IV	140	—	87	—
	Jan	I	210	—	140	—
	,,	II	275	—	185	12 / 6.48
	,,	III	442	26 / 5.88	278	24 / 8.63
	,,	IV	338	28 / 8.28	345	50 / 14.49
	Feb	I	425	45 / 10.58	390	78 / 20.00
	,,	II	538	88 / 16.35	452	129 / 28.53
		ETAWAH			JAUNPUR	
1980—1981	Jan	I	310	—	128	—
	,,	II	352	20 / 5.68	210	14 / 6.66
	,,	III	475	42 / 8.42	314	31 / 9.87
	,,	IV	498	66 / 13.25	328	46 / 14.02
	Feb	I	510	78 / 15.29	405	81 / 20.00
	,,	II	524	116 / 22.13	412	108 / 26.21
	,,	III	605	182 / 30.08	518	197 / 38.03
	,,	IV	692	245 / 35.40	626	282 / 45.04
	Mar	I	490	201 / 41.02	380	195 / 51 31
	,,	II	325	156 / 48.00	272	152 / 55.88
		MATHURA			ALLAHABAD	
1981—1982	Dec	I	145	—	98	—
	,,	II	192	—	104	—
	,,	III	256	—	122	—
	,,	IV	280	—	154	—
	Jan	I	358	—	220	18 / 8.18
	,,	II	510	26 / 5.09	342	42 / 12.28
	,,	III	572	41 / 7.16	390	78 / 20.00
	,,	IV	625	90 / 14.40	425	115 / 27.05
	Feb	I	520	96 / 18.46	405	154 / 38.02
	,,	II	552	144 / 26.08	442	216 / 48.86

TABLE 2. Table showing the percentage of *Chromatomyia horticola* on *Pisum sativum* in humid zone of Himachal Pradesh.

	Rainfall			Above 140 cm
	Average max. temp.			17.5–21.2°C
	Average R. H.			74.5–80 5%
Year	Month	Week	No. of larvae	Larvae parasitised by *D. isaea* No. / %
1980	June	I	82	26 / 31 70
	,,	II	115	30 / 26.08
	,,	III	138	51 / 36.95
	,,	IV	124	48 / 38.70
1981	June	I	88	22 / 25.00
	,,	II	122	36 / 29.50
	,,	III	130	48 / 36.92
	,,	IV	125	50 / 40.00

(65.5—70.2%) results in highest parasitism. In the humid zone, where lower average maximum temperature (17 5—21.2°C) and high average relative humidity (74 5—80.5%) conditions exist, the lowest parasitism were recorded.

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STUDIES ON DOUBLE COCOONS IN SILKWORM *BOMBYX MORI* L. AND THEIR UTILIZATION IN LAYING PREPARATION

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In NB_4D_2 breed of the silkworm, *Bombyx mori* the combination of female + female, female + male and male + male pupae was 30.00, 46.66 and 23.33 per cent, respectively in the double cocoons. Utilization of moths emerged from double cocoons in preparation of disease free layings tended to have little effect on fecundity, rate of hatching, larval weight, effective rate of rearing, further formation of double cocoons, cocoon weight and shell percentage.

(Key words: mulberry silkworm, *Bombyx mori,* double cocoon)

INTRODUCTION

Double cocoon formation in the silkworm, *Bombyx mori* L. is known to be caused by high density of mounted worms on mountage. It is also governed genetically and more common in univoltine and bivoltine breeds. KUMARARAJ (1968) studied the combination of sexes in double cocoons and concluded that male + female, male + male and female + female combination was 47.42, 21.90 and 30.63 per cent. There is general belief that double cocoons should not be employed in preparation of disease free layings which may be due to the presumption that the resulting progeny will also have the same feature of double cocoon construction. Observations were made on the double cocoons in the silkworm, *Bombyx mori* L. and the possibility of utilizing the moths emerged from such double cocoons for laying preparation and further rearing of silkworm and the results are presented in this paper.

MATERIALS AND METHODS

The study was carried out in the Sericulture Section, Dapartment of Agricultural Entomology, Agricultural College, University of Agricultural Sciences, Bangalore during 1983. The bivoltine silkworm breed NB_4D_2 was employed. Double cocoons were selected at random from a cocoon lot at a time in four replications with 60 cocoons per replication and their pupal sex analysis was done. The single cocoons were also selected in the same lot. The following crosses were effected and layings were prepared.

(1) Double cocoon female × Double cocoon male; (2) Double cocoon female × Single cocoon male; (3) Single cocoon female × Double cocoon male; (4) Single cocoon female × Single cocoon male.

Five disease-free layings were used for determining the number of eggs per laying and the same layings were employed for finding out per cent hatching in each replication and five such replications were maintained for each treatment. A total of 2,000 larvae were reared in five replications in each treatment. The ripe worms were mounted at the rate of 50 worms/ft². Observations were recorded on maximum larval weight, effective

rate of rearing, cocoon weight, pupal weight and shell weight. All the data were analysed statistically and inference drawn.

RESULTS AND DISCUSSION

The results of the study are discussed below. The sex analysis of double cocoons revealed the combination of female + female, female + male, and male + male to be 30 00, 46.65 and 23 33 per cent, respectively. The association of female in the double cocoon was to the extent of 76 65 per cent while that of male was 70 00 which is in conformity with the observations of KUMARARAJ (1968) who observed the frequency of occurrence of female in general to be more than male in double cocoons. NAGARAJA RAO & PRAHLADA RAO (1961) also made similar observations. TALUKDAR (1961) encountered double cocoon formation in muga silkworm, *Antheraea assama* Westwood and eri silkworm, *Philosamia ricini* Hutt. But in eri double cocoons only females were noticed. This deviation from the current observation may be attributable to the species variation.

The mean number of eggs/DFL ranged from 488.00 to 537.80 in respect of double cocoon female while it varied from 496.80 to 590.80 in case of single cocoon female (Table) and no statistical difference existed in fecundity.

The percentage of hatching involving double cocoon female and single cocoon female was between 94.19 to 96.01 and it was statistically similar in the crosses experimented. The maximum larval weight of ten worms was more (30.93 g) in respect of double cocoon female × double cocoon male. The larval weight was statistically non-significant in respect of double cocoon female × single cocoon male, single cocoon female × double cocoon male and control while these differed statistically with that resulted from double cocoon female × double cocoon male. The effective rate of rearing ranged from 79.80 to 92.20 per cent (Table). Effective rate of rearing resulting from double cocoon female × double cocoon male and control remained on par with each other. Further, double cocoon formation was seldom encountered in any of the treatments. The weight of ten cocoons varied between 13.60 to 13.80 g and no statistical difference existed amongst them. Similarly, the weight of 10 pupae amongst the treatments ranged between 11.41 to 11.51 g with no statistical difference. The shell percentage (16.55 to 18 48) also remained similar with each other under the experimented crosses. Literature on this aspect is little to discuss.

Since double cocoon formation is recognised as a genetic trait, detailed studies on the performance of progeny, resulting from the double cocoons, in subsequent generations too is a requirement in reproductive silkworm seed production. The present study has indicated that there is little effect of employing moths emerged from double cocoons of NB_4D_2 breed on most of the parameters in F_1 generation. In view of the above, it may be suggested that the moths emerged from double cocoons of NB_4D_2 be used in preparation of commercial DFL's of multi-voltine × bivoltine NB_4D_2 as well as bivoltine hybrids involving NB_4D_2 as one of the parents, the cocoons produced from which are used as reeling cocoons.

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TABLE 1. Effect of utilizing moths emerged from double cocoons on fecundity, hatching, larval weight, effective rate of rearing, cocoon weight, pupal weight and shell percentage.

Treatments	Fecundity	Per cent egg hatching	Maximum larval weight (g) (10 worms)	Effective rate of rearing (per cent)	Double cocoons formed	Cocoon weight (g) (10 cocoons)	Pupal weight (g) (10 pupae)	Shell Percentage
1. Double cocoon female × Double cocoon male	488.0	95.39 (78.56)*	30.93	92.00 (73.66)	—	13.70	11.18	18.48 (25.48)
2. Double cocoon female × Single cocoon male	537.80	94.30 (76.84)	29.42	79.80 (63.30)	—	13.60	11.16	17.93 (25.04)
3. Single cocoon female × Double cocoon male	590.80	94.19 (77.44)	28.28	82.00 (64.92)	—	13.79	11.41	17.19 (24.48)
Control:								
4. Single cocoon female × Single cocoon male	496.80	96.01 (78.74)	29.45	92.20 (73.90)	—	13.80	11.51	16.55 (24.02)
SEM ±	—	—	0.24	0.66	—	—	—	—
CD (5%)	NS	NS	1.22	3.28	NS	NS	NS	—

* Figures in the parenthesis are angualar transformed values.

NS = not significant.

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INFLUENCE OF CERTAIN AMINO ACIDS IN PADDY VARIETIES ON THE INFESTIVE ABILITY OF LESSER GRAIN BORER *RHIZOPERTHA DOMINICA* (FAB.)

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Seven amino acids considered to be important from insect dietetics point of view, namely, lysine, leucine tryptophan, methionine, tyrosine, cystine and phenyl-alanine from 12 paddy varieties (grain) out of which six rated as resistant and the rest as susceptible to the pest were bioassayed to evaluate their impact on the infestive ability of the lesser grain borer, *Rhizopertha dominica* (Fab.), a serious pest of rice in storage. The correlation between the concentration of lysine, leucine, phenyl-alanine and tryptophan and the incidence was found to be positive, while the two sulphur-containing amino acids viz., methionine and cystine recorded negative correlation with the infestation.

(Key words: amino acids, lesser grain borer, infestive ability, insect dietetics, host plant resistance, biological parameter)

INTRODUCTION

Of late, it has been well-documented that the amino acid composition of the host, exercises great influence on the infestive ability of the insect pest, as an inportant factor of antibiosis in host plant resistance to pests. While there are a few outstanding contributions on the role of the amino acids in host plant resistance of some phytophagous pests (AUCLAIR *et al*, 1957; BECK, 1950; HOUSE, 1965; KALOLE & PANT, 1967; PAINTER, 1969; PANDA & DAS, 1975), very little work has been reported on the specific role of individual amino acids in stored grains, in relation to their susceptibility or otherwise. This paper deals with the work on certain amino acids present in paddy varieties (grain) and their impact on the infestive ability of the pest, the lesser grain borer, *Rhizopertha dominica* (Fab), which is a serious and regular pest on stored rice.

MATERIAL AND METHODS

Twelve popular and high yielding paddy varieties were selected for these investigations essentially based on their earlier record of infestability to the lesser grain borer and other stored pests. The test varieties were divided into two groups of six each, namely, susceptible from serial numbers 1 to 6 and resistant from serial numbers 7 to 12 (Table 1). The grain samples of the test varieties were drawn from the lots maintained at $30\pm1°C$ temperature and 14 ± 0.5 per cent grain moisture level, as the above level of temperature-moisture combination was found to be the most congenial for the pest in the studies conducted by the authors. Standard microbiological techniques (BURTON WRIGHT) were adopted for determining the amino acid

composition of the grain. The seven amino acids bioassayed are: D- lysine (x_1), DL-leucine (x_2), DL- trypotphan (x_3), L- methionine (x_4), L-tyrosine(x_5), L- cystine (x_6), and DL- phenyl-alanine (x_7). These amino acids were included in the study on the basis of their significance in the insect dietetics.

The infestation indices (biological parameters), namely, the number of eggs laid (Y1) and the number of adults emerge. (Y2) were selected for the studies as these parameters were reckoned by many workers to reflect the infestive capacity of the pest more accurately.

Correlations and multiple regressions were worked out treating the two biological parameters as dependent variables (Ys) and the amino acids as independent variables (Xs).

RESULTS AND DISCUSSION

The correlation between the number of eggs laid (Y1), and each one of lysine (x_1) leucine (x_2), phenyl-alanine (x_3) and tryptophan (x_4), was positively signifibant (Table 1). It was found that higher the concentration of these amino acids in grain, higher was the infestation and therefore, higher the preference of the pest to these amino acids. But methionine (x_5) and cystine (x_6) were negatively correlated with fecundity (Y1) and therefore, increased titres of these amino acids had resulted in decreased oviposition. However, the varietal differences for tyrosine (x_7) were not significant.

In respect of the other biological parameter i. e., the number of adults emerged (Y2), similar trend as in number of eggs laid was noticed.

Higher values of lysine and leucine present in the grain favoured the pest in a significant way (Table 1) According to GUPTA *et al.* (1970) higer lysine content in maize significantly increased weevil infestation. BHARAT (1970) working on *Callosobruchus maculatus* (Fab.) observed in pulses that lysine and leucine are associated with higher bruchid preference; LECATO & AGROBAS (1974) found that high lysine maize hybrids had higher red rust flour beetle infestation. SUDHAKAR & PANDEY (1981) reported that susceptible varieties of maize and rice respectively to *Sytophilus oryzae* contained higher number of amino acids than resistant ones. The results of the present studies are in conformity with those of the above workers. Our results further suggest that phenyl-alanine and trypotphan are also associated with susceptibility of the pest as in the case of lysine and leucine. PANDA (1979) studied the influence of phenyl-alanine and tryptophan in host plant resistance. He concluded that these amino acids should be in sufficient quantities to cope up with insect's demands at different stages of its growth,

The two sulphur-based amino acids, namely, methionine and cystine were found to be negatively correlated with infestation by *R. dominica* (Tables 2 and 3) contrary to what has been reported by JAYARAJ (1964) that the fee amino acids cystine and methionine were prominent in susceptible varieties of castor to leafhopper. This might be ascribed to the peculiar requirements of the lesser grain borer as a stored grain insect.

The results of multiple regression analysis furnished below reveal that eventhough the regression coefficient (r) was found to be as high as 0.97 in both the biological parameters (Y1 and Y2) there was no significant relationship between the two infestation indices (Y1 and Y2) and the amino acids (x_1, x_2 .. ..x_7).

TABLE 1. Amino acid composition of grain (paddy and rice) and infestation by *R. dominica*.

Sl. No.	Variety	Biological parameters in paddy amino acids mg / 16 8 gm of protein								
		No. of eggs laid	No. of adults emerged	Lysine	Leucine	Phenyl alanine	Tryptophan	Methionine	Cystine	Tyrosine
		Y1	Y2	X_1	X_2	X_3	X_4	X_5	X_6	X_7
1.	IR 26	184.00	180.50	3.59	8.52	6.38	1.00	1.84	1.60	2.47
2	RP 193-1	165.00	157.50	2.35	8.40	6.35	1.03	1.82	1.63	2.37
3	Mashuri	160.00	152.00	3.49	8.22	6.13	0.95	2.10	2.30	2.48
4.	Imp. Sona	156.00	147.50	3.12	8.33	6.03	1.03	1.79	1.71	3.00
5.	Ratna	140.00	130.50	3.10	9.33	6.20	0.96	1.89	1.96	3.36
6.	IR 20	142.00	131.00	3.31	9.05	6.23	0.99	2.01	1.71	3.36
7.	8002	136.00	120.00	2.99	8.05	5.82	0.90	2.09	2.22	4.08
8.	80-9	134.00	118.00	2.98	7.56	5.73	0.96	2.10	2.39	3.94
9.	Jaya	126.00	108.50	3.02	8.97	5.90	0.85	2.28	1.88	4.26
10.	Vijaya	119.50	101.50	3.08	8.81	5.55	1.01	2.15	2.44	4.80
11.	SLO 13	114.00	95.00	3.08	8.10	5.81	0.76	2.19	2.46	4.13
12	Jagannath	110.00	90.00	2.93	8.16	5.72	0.77	2.31	2.68	4.62

The biological parameters were recorded at a grain temperature and moisture regimes of 30°C and 14 per cent respectively. Among the varieties S. Nos. 1 to 6 are susceptible and 7 to 12 are resistant.

TABLE 2. Relation between amino acid composition of grain (paddy) varieties and infestation (number of eggs laid by *R. dominica*).

Amino acid	Lysine	Leucine	Phenyl alanine	Tryptophan	Methionine	Cystine	Tyrosine	r Value
Lysine	*0.3492*	−0.0012	0.0795	0.0523	0.1579	0.2416	0.0036	0.8434**
Leucine	0.2763	*−0.0015*	0.0742	0.0702	0.2290	0.2593	−0.0074	0.8337**
Phenyl alanine	0.1776	−0 0007	*0.1563*	0.0746	0.1760	0.1674	−0.0485	0.7026*
Tryptophan	−0.1920	0.0011	−0 1225	*−0.0952*	−0.2140	−0.2256	0.0370	0.8111**
Methionine	−0.1978	0.0012	−0 0988	−0.0731	*−0.0279*	−0.2008	0.0946	−0.7534**
Cystine	−0.2935	0.0014	−0.0910	−0.0910	−0.1947	*−0.2875*	0.0105	−0.9296**
Tyrosine	0.0613	−0.0005	0.0370	0.0172	0.1286	0.01147	*−0.2050*	0.0532 NS

The values in italics are direct values.
* Significant at $p = .05$
** Significant at $p = .01$
NS = Not significant.

TABLE 3. Relation between amino acid composition of grain (paddy) varieties and infestation (No. of adults emerged) by *R. dominica*.

Matrix of (Direct and indirect) path coefficients.

Amino acid	Lysine	Leucine	Phenyl alanine	Tryptophan	Methionine	Cystine	Tyrosine	r Value
Lysine	*0.1969*	1.1041	0.2870	0.0213	0.0810	0.5551	0.0835	0.8471**
Leucine	0.1001	*1.3955*	0.2679	−0.0285	−0.1175	0.5958	−0.1709	0.0508**
Phenyl alanine	0.1001	0.6623	*0.5645*	−0.0303	−0.0900	−0.3845	−0.1127	0.7091**
Tryptophan	−0.1082	−1.0290	−0.4422	*0.0387*	0.1010	0.5184	0.0860	−0.8268
Methionine	−0.1116	−1.1467	−0.3566	0.0297	*0.1430*	0.4614	0.2196	−0.7611**
Cystine	−0.1655	−1.2589	−0.3286	0.0303	0.0999	*0.6604*	0.0243	−0.9381**
Tyrosine	0.0345	0.5010	0.1336	−0.0070	−0.0660	−0.0337	*−0.4760*	0.0865 NS

1. The values in italics are direct values.
2. *Significant at $p = .05$
**Significant at $p = .01$
NS = Not significant.

Number of eggs laid = Y1 = $154.1210 + 36.3839\ x_1 - 0.1234\ x_2 + 36.7775\ x_3$ $11.9233\ x_4 - 16.4422\ x_5\ 7.48262\ x_6 - 9.1087\ x_7$.

Number of adults emerged = Y2 = $129.9614 + 41.5420\ x_1 + 1.5417\ x_2 + 42.3620\ x_3$- $20\ 67.64\ x_4 - 16\ 0098\ x_5 - 10.2240\ x_6 - 8\ 3123$ x_7.

It is evident from the above equations that apparently there was no relationship with any one of the amino acids (xs) individually with either of the two biological parameters (Ys). This discrepancy was resolved with the help of path coefficient analysis according to the procedures of DEWY & LO (1949) using the correlation between the amino acids and the two biological indices. The data on number of eggs laid (Table 2) indicated that lysine was found directly contributing but indirectly through lysine and cystine; cystine was directly contributing but indirectly through lysine and methionine. The amino acids lysine, methionine and cystine accounted for most of the variation in case of number of eggs laid.

However, in respect of number of adults emerged (Table 3), leucine was directly contributing but indirectly through phenyl-alanine and lysine, phenyl-alanine was directly contributing but through leucine and cystine indirectly. Cystine was directly contributing but indirectly through leucine and phenyl-alanine. The amino acids which contributed to most of the variation in case of number of adults emerged (Y2) were found to be leucine, phenyl-alanine and cystine

Thus, interestingly, in both the biological parameters phenyl-alanine and cystine were found to contribute significantly. This study has thrown new light on the key role played by some amino acids in the host on the infestive ability of the pest.

From these studies it can be concluded that certain amino acids in the grain play a vital role in determining the susceptibility status of some paddy varieties to *R. dominica*. Further research on these aspects would be imperative, to clearly understand the role of amino acids in the infestability of stored grain varieties to different pests.

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EFFECT OF IRRIGATION ON PERSISTENT TOXICITY OF INSECTICIDES APPLIED AS GRANULES TO SOIL TO BROWN PLANT HOPPER AND RICE SWARMING CATERPILLAR

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Field studies were undertaken to ascertain effect of irrigation at field capacity and 2.5 cm depth of water levels on the uptake and persistence of the insecticides carbofuran (1.0 kg ai/ha), phorate (2.0 kg ai/ha) and mephosfolan (1.0 kg ai/ha) against brown plant hopper and rice swarming caterpillar, when applied as granules to soil at 21 and 45 days after transplanting (DAT). PT index values for carbofuran and phorate to BPH were higher at field capacity level than at 2.5 cm water level when applied 21 DAT. At 45 DAT, PT index values were higher at 2.5 cm water level for carbofuran and phorate while the values were reversed with mephosfolan. The overall persistence was maximum for carbofuran. To rice swarming caterpillar the PT index values were higher for all the three insecticides at the field capacity level at both the crop stages and the maximum persistence and toxicity were shown by mephosfolan.

(Key words: rice pests, control, persistent toxicity, systemic insecticides)

INTRODUCTION

Among the advantages of the use of insecticides in the form of granules for insect control is the ease of application coupled with its efficiency. Efficacy of toxicants applied to soil on the pests is bound to be governed by the systemic and persistent actions Systemic insecticides with good persistence have been found more effective in the control of rice pests than the non-systemic ones w·en applied as granuals (MATHAI *et al*, 19̄5). But insecticides like phorate and mephosfolan were found less toxic and persistent to brown plant hopper than carbofuran under flooded condition (MATHAI *et al.*, 1976; RAJAKKANNU *et al.*, 1977) Rapid biodegradation of corbofuran was reported under flooded condition (VENKATESWARALU *et al.*, 1977). RAJAKKANNU *et al.* (1977), MOHANDAS & VISALAKSHI (1978), and SAIVARAJ & VENUGOPAL (1978; 1979) reported higher persistence of insecticide granules at field capacity level than at other levels of irrigation. As the rice crop requires insecticide application at different growth stages, against different types of pests, studies were undertaken to ascertain the persistent toxicity of some insecticide granuales applied at tillering and boot-leaf stages of the crop under flooded and field capacity levels of irrigation.

MATERIALS AND METHODS

The field experiment was conducted at the Instructional Farm, College of Agriculture, Vellayani, Kerala State, using a split plot

layout in randomised block design with three replications. The gross plot size was 2.0 m × 1.5 m with alternate buffer plots. Seedlings of *Jaya* variety of rice were planted at a spacing of 15 × 10 cm. The net plot size was 1.40 m × 1.11 m with 99 hills of paddy. Separate channels were provided for drainage and irrigation. The irrigation levels were field capacity level (FCL) and 2.5 cm depth of water level (flooded) which were sub-plot treatments.

Carbofuran (Furadan 3 G) at 1.0 kg ai/ha, phorate (Thimet—10 G) at 2.0 kg ai/ha and mephosfolan (Cytrolane-5G) at 1.0 kg ai/ha were applied at tillering (21 DAT) and at boot leaf (45 DAT) stages of the crop as main plot treatments.

Persistent toxicity of the insecticides was estimated by exposing brown plant hopper (BPH) and rice swarming caterpillar (RSC) to the treated plants at different intervals after treatment and mortalities observed. For this individual hills of plants with undisturbed root zone were uprooted from the treated plots 6 hours, 12 hours, 24 hours after insecticide application and then at daily intervals and planted in small pots of 15 cm diameter filled with soil collected from untreated plots. Basal portion of three tillers from each of these hills were enclosed in open glass tubes of 3 cm diameter. Third instar nymphs of BPH of cultures maintained in the laboratory were released into each tube at the rate of 20 nymphs per tube and the tubes closed with cotton plug permitting excess lengths of the plants jutting out of the tubes. For RSC, the potted plants were enclosed in hurricane glass chmineys and ten numbers of third instar larvae of uniform size, reared in the laboratory, released on the plants. Mortalities of the test insects were observed 48 hours after release and the experiment continued till no mortality was observed on the treated plants. Persistent toxicity of the insecticides was expressed as PT index (PRADHAN, 1967).

RESULTS AND DISCUSSION

Against BPH (Table 1) carbofuran and phorate when applied at 21 DAT showed higher initial and maximum toxicity at the field capacity level of irrigation than at a level of 2.5 cm of water. The maximum toxicity to BPH was attained in 12 hours at both the irrigation levels with carbofuran while with phorate it took 2 days at 2.5 cm level and only 12 hours at field capacity level. The PT index which gave an overall indication of the combined effect of toxicity and persistence was much higher (496) at field capacity level than at 2.5 cm level (294) for carbofuran and 270 and 172 respectively for phorate. When applied at 45 DAT, however, these relative position of the effect, parameters were reversed the maximum toxicity and PT index of carbofuran and phorate being lower at field capacity level than at 2.5 cm level.

In the case of mephosfolan when applied at 21 DAT the toxicity to BPH as well as the PT index values were higher at 2.5 cm water level than at field capacity level. When applied at 45 DAT, however, these were reversed and higher toxicity and PT index value could be observed at field capacity level than at 2.5 cm level.

With rice swarming caterpillar (Table 2) the toxicity parameters and PT index values were higher at field capacity level than at 2.5 cm water level for carbofuran, phorate and mephosfolan applied at both the stages of 21 and 45 DAT.

Increased degradation of carbofuran in soil under flooded conditions reported by VENKITESWARLU *et al.* (1977) and RAJAKKANNU *et al.* (1977) was generally reflected in the present results also. The behaviour of phorate observed here agreed with the findings of AGNIHOTRI (1978) and MOHANDAS & VISALAKSHI (1978). The reversal of responses shown by BPH at the two stages of plant growth appeared to be related to the variation in the feeding habits of the insect on

TABLE 1. Effect of irrigation on persistent toxicity of systemic insecticides to BPH when applied in soil as granules at two growth stages of rice.

Effect parameters	Growth stage (DAT)	Carbofuran		Phorate		Mephosfolan	
		Fl	Fc	Fl	Fc	Fl	Fc
Per cent mortality 6 h after treatment	21	39.3	50.6	30.5	46.7	24.8	19 1
	45	29.5	19.8	0.0	6.5	0.0	7.7
Maximum mortality (%) on treated plants	21	59.6	80.3	40.8	77.3	60.3	40.3
	45	58.3	24.9	36.8	18.0	16.8	28.3
Time taken after treatment to reach max. mortality (%) on plants	21	12 hr	12 hr	2 days	12 hr	2 days	2 days
	45	24 hr	24 hr	12 hr	4 days	4 days	3 days
Period (days) upto which toxicity persisted (P)	21	14	15	8	8	9	11
	45	15	12	8	8	11	10
Average toxicity (T)	21	21 0	32.8	21.5	33 7	29.3	18.6
	45	24 2	18.7	18.8	11.6	11.7	16.1
PT index	21	294	496	172	270	269	205
	45	363	225	150	90	129	161

Note: BPH—Brown plant hopper; DAT—Days after transplantation; Fl—2.5 cm of water; Fc—Field capacity level.

TABLE 2. Effect of irrigation on persistent toxicity of systemic insecticides to swarming caterpillar when applied in soil as granules at two growth stages of rice.

Effect parameters	Growth stages (DAT)	Carbofuran		Phorate		Mephosfolan	
		Fl	Fc	Fl	Fc	Fl	Fc
Per cent mortality 6 hr after treatment	21	19.7	79.8	0.0	0 0	80.0	100.00
	45	0 0	12.5	0.0	0 0	100.0	100.0
Maximum mortality (%) on treated plants	21	52.9	79.8	9 1	12.0	100.0	100.0
	45	25.0	37.5	12.5	31 3	100.0	100.0
Time taken after treatment to reach maximum mortality	21	2 day	6 hr	24 hr	24 hr	6 hr	6 hr
	45	24 hr	24 hr	2 days	2 days	6 hr	6 hr
Period (days) upto which toxicity persisted (P)	21	6	7	3	3	14	16
	45	3	5	4	5	14	17
Average toxicity (T)	21	24 4	36.7	3 0	4.0	54.9	65 2
	45	13 9	19 5	4.9	14.7	64.1	60 2
P T index	21	146	257	9	12	769	1044
	45	40	98	19	74	897	1023

Note: DAT—Days after transplantation; Fl –2.5 cm of water; Fc—Field capacity level.

the two stages and to the rate of translocation of the toxicants to the different plant parts.

From the practical point of view, carbofuran granules applied at field capacity level of irrigation during the early stages and with water 2.5 cm deep during the later stages of the crop appeared to be the best treatments for the control of BPH. For the control of rice swarming caterpillar mephosfolan was the most effective at both the growth stages of the crop.

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TWO NEW SPECIES OF THRIPIDAE (INSECTA: THYSANOPTERA) FROM INDIA

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(Received 14 April 1984)

Two new species of Thripidae (Thysanoptera), *Exothrips jammuensis* sp. nov. from Jammu-Kashmir and *Thrips sensarmai* sp. nov. from Darjeeling (West Bengal) are described. *Exothrips jammuensis* sp. nov. shows laterally directed teeth on postmarginal flange on III to VIII terga, well developed fore tibial tooth and expanded lateral major setae on terga IX and X in male. *Thrips sensarmai* sp. nov. is brown in colour and has 3 lateral marginal setae on II tergum.

(*Key words: Exothrips jammuensis* sp. nov., *Thrips sensarmai* sp. nov. new Thysanoptera, Thripidae)

This article includes description of two new species of Thripidae (Thysanoptera): *Exothrips jammuensis* sp. nov. from Jammu and Kashmir and *Thrips sensarmai* sp. nov. from Darjeeling (West Bengal). All measurements given in the following description are in micrometer (μm).

Exothrips jammuensis sp. nov. (Figs. 1-6)

Female (macropterous): Body yellow including legs; abdominal segment X brown at extreme posterior end. Antennal segments I to III concolorous with body; IV brown in distal one fourth; V dark brown in basal and in distal one third, rest basal lighter; VI to VIII dark brown. Pretarsal plates dark brown. Setae yellow. Wings pale yellow. Ocellar crescent orange.

Head L 66-70, W at eyes 105-110, W at cheeks 100-105, ventral length upto transclypeal suture 114-116. Mouth cone at the level of maxillary palpi bases 38-43 wide, midway between this and apex of mouth cone 32-35 wide, at apex 19-20 wide. Anteocellar setae 2 pairs interocellar setae placed at inner angle of posterior pair of ocelli: anteocellar and interocellar setae 5-7 long; postocular setae I developed and subequal to II setae. Maxillary palpi 3-segmented. L (W) of segment: I 22-23 (6), II 11-13 (4), III 15-16 (3); labial palpi 15-17 long. Antennae 8-segmented 205-208 long, L (W) of segment: I 16 (25), II 28-30 (22), III 31-34 (19), IV 26-30 (16-18), V 26-29 (16-18), VI 31-34 (14-16), VII 6-7 (6), VIII 10-13 (4-5). Microtrichia present on segments III-VI; setae on antennal segments: I 6-5 II 7, III 5, IV 6, V 8, VI 10, VII 4, VIII 9.

Pronotum longer than wide, L 145-150, W at anterior margin 110-122, W at posterior margin 145-165; posteromarginal setae 5 pairs; posteroangular setae, outer 15-19 and inner 10-12 long;

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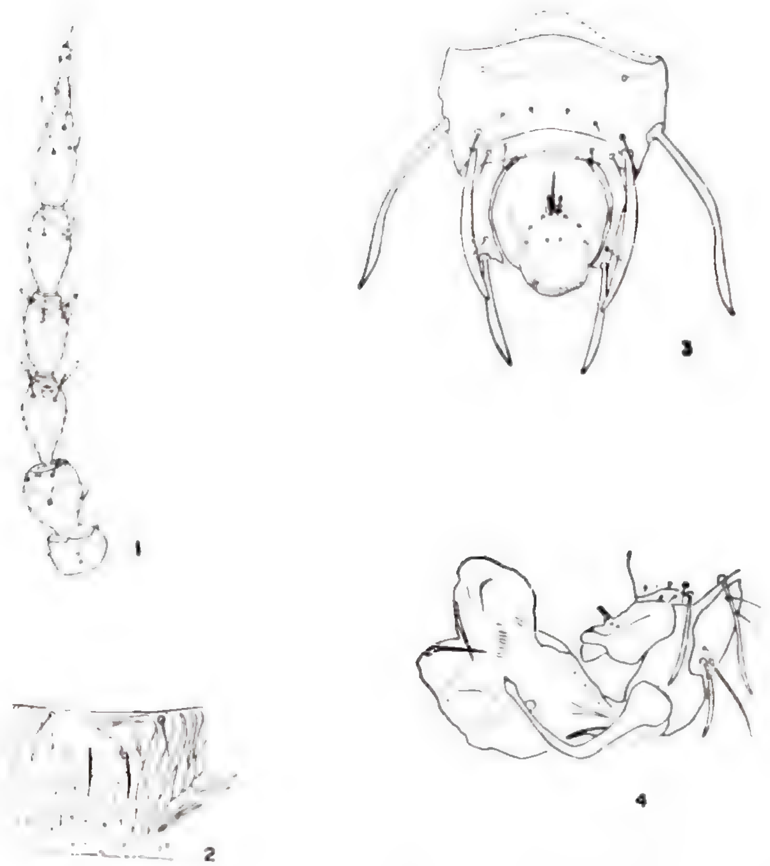


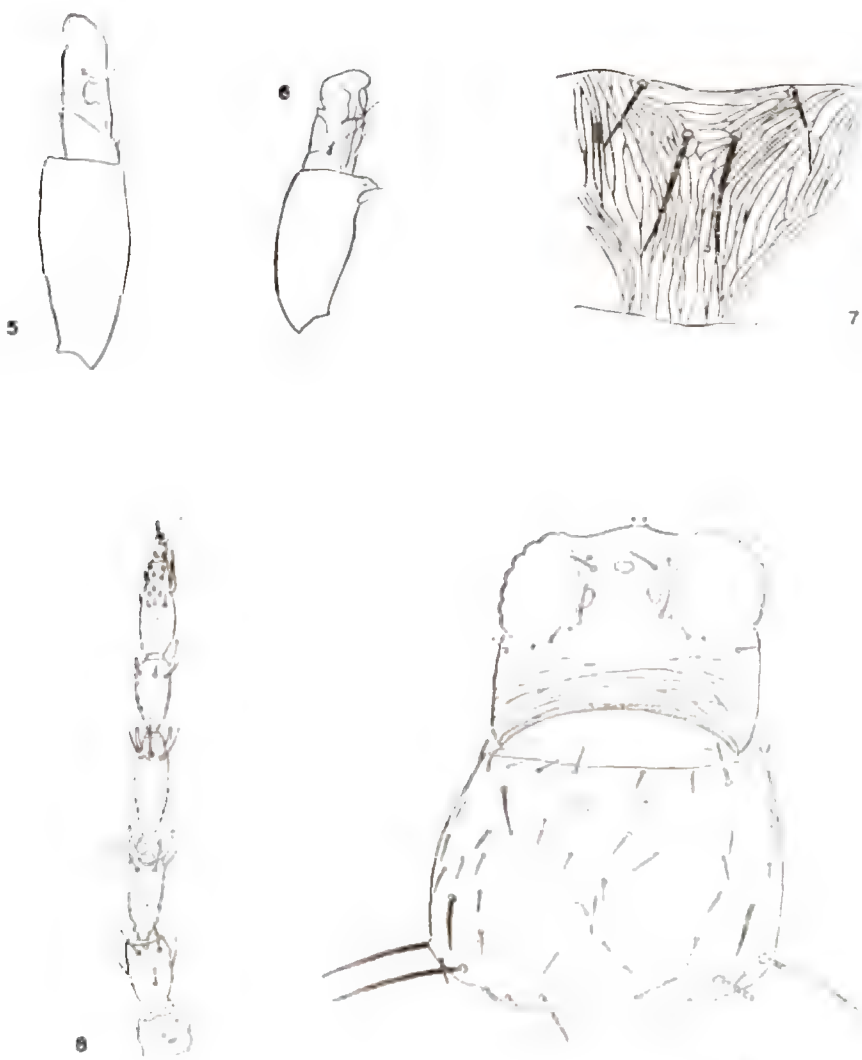
Figs. 1—4. *Exothrips jammuensis* sp. nov., 1-Antenna, dorsal, ♀ (paratype); 2—Mesonotum, ♀; 3—Terminal abdominal segments, ♂ (allotype); 4—membranous phallus organ along with hypophallus, lateral view of fully distended organ.

surface with weak transverse anastomosing lines of sculpture. Mesonotum with median pair of setae far ahead (25-26) of posterior margin; surface with transverse anastomosing lines of sculpture. Metanotum with longitudinal, nearly parallel lines on lateral side but medially anastomosing lines of sculpture; median pair of setae inserted far back (13-15) of anterior margin, interval between these setae about equal to the interval between the median and submedian setae on either side; median pair of setae 19-25 long, submedian setae 17-20 long; companiform sensillae present. Ferna incomplete. Basantra membranous without setae.

Fore wings L 602-616 long, W at middle 31-36. Costa with 19-22 setae, costal setae at middle of the wing 22-25 long; upper vein with 1+3+3 basal and 1+1+1 distal setae; lower vein with 4 setae, interval between the first and the second setae is much less (63-72) than that between second and third (94-105) but almost equal to that between third and fourth (69-78). Scale with 5+1 setae. Fore tibia at apex without

tooth, stout seta present on slightly projected base. Fore femur 90-105 long 60-66 wide at middle. Hind tibia 116-120 long with a row of 6-7 short stout setae.

Abdomen terga I to VIII completely sculptured with transverse lines but more prominently on tergum I. Tergum II with III lateral marginal setae, seta S4 absent on terga VI-VIII. Terga V-



Figs. 5—8. *Exothrips jammuensis* sp. nov., 5—a part of foreleg, ♀ (paratype); 6—a part of fore leg, ♂ (allotype); 7—9. *Thrips sensarmai* sp. nov., 7—Mesonotum, ♀; 8—Antenna, dorsal, ♀; 9—Head and prothrorax, dorsal, ♀ (paratype).

VIII with a few rows of microtrichia along lines of sculpture on extreme sides. Spiracle on II segment elongate, 22-25 long, 10-11 wide. Sternum VII with well developed S1-S3 setae and S1 and S2 approximated, setae S1 ahead of posterior margin and 16-17 from each other, 10-12 apart from S2. Seta on IX: S1 63-70, md 26-35 (70-100 away from each other), S2 65-79, S3 65-79, S4 50-69; on X: S1 69-76, S2 70-79, S3 44-50. Tergum X with dorsal cleft present on its entire length, 59-61 long. Ovipositor 227-240 long. Total body length: 910-980; in distended: 1288.

Male (macropterous): Body similar to female. Antennal segments I-IV pale yellow, V greyish brown in distal one third, VI brown but lighter towards base, VII-VIII brown.

Head L 41-45, W at eyes 98-101, W at cheeks 91-93, ventral length till apex of mouth cone 137-148. Antennae 174-177 long, L(W) of segments: I 16-17(22), II 22-25(21-22), III 29-31(16), IV 28(16), V 25-26(16), VI 26-28(16), VII 6(6), VIII 9-10(4).

Pronotum L 142-145, W at anterior margin 94-96, W at posterior margin 132-136. Fore wings 526-546 long, W at middle 26-31. Costa with 19-22 setae; upper vein with 1(minute)+3+3 basal and 1+1+1 distal setae; lower vein with 4 setae, interval between first and second much less (35-38) than that between second and third (82-84) or between third and fourth (94-96). Costal fringes after 7th costal seta interval between first and second costal setae 47-50. Scale with 5+1 setae. Fore femur somewhat enlarged L (anteroposteriorly) 95-100, W at middle 53-54. Fore tibia at apex with short stout tooth, 10-11 long. Abdominal terga III-VIII with finely pointed triangular teeth on either sides of postmarginal flange directed laterally, in middle of flange of terga II-VIII without such teeth Sterna without gland areas or accessory setae. Tergum IX with a pair of sickle like hyaline setae on sides. Tergum X with a pair of stout small seta (8-10 long). Placed on projected base. Phallus with two prominent spikes. Total body length (distended): 784-800 (excluding parameres).

Material examined: **Holotype** ♀, **allotype** ♂, Jammu and Kashmir, Katra: Ardhakuwari Ganga, ex leaves of *Salix terasperma* (Salicaceae), 11.viii 1980, leg Vijay Veer; **Paratypes** 10♀♀, 1♂ with the same data along with larvae.

Remarks: This new species may be compared with *Exothrips redox* Bhatti 1975 which has subequal S1 and S2 setae on sternum VII in female, laterally directed teeth on postmarginal flange on tergum IV-VII and foretibial tooth in male. *Exothrips jammuensis* sp. nov. is readily separated from *redox* by the longer mouth cone, 3 lateral marginal setae on tergum II and tergum X (male) with thick and stout seta placed on a raised prominence and by major lateral setae on tergum IX-X expanded like sickle

Thrips sensarmai sp. nov. (Figs. 7-9)

Female (macropterous): Body brown to dark brown with orangish hypodermal pigments in head and thorax and in II antennal segment, in some specimens abdomen dark brown, and head and pterothorax lighter. Antennae dark greyish brown except segments I to II and basal one fourth of III segment light brown. All tarsi yellow and all femurs and tibia yellowish brown in

middle. Fore wings infumated but lighter in basal portion. Major setae dark and ocelli crimson red.

Head wider than long, L 110-126, W at eyes 146-153, W at cheeks 151-172: interocellar setae 25-28 long and inserted outside ocellar triangle, just touching tangent along outer margins of fore and hind ocelli on either side, anteocellar setae short, 10-13 long; postocular setae II and IV minute, length of these: I 29-32, II 9-10, III 19-22, IV 9-10. Maxillary palpi 3-segmented, L(W) of I-III: 18-22(9), 10-16 (6), 20-29(4-5); labial palpi 24-26 long. Antennae 7-segmented, 294-336 long, L(W) of I-VII: I 22-28(28-31), II 32-43 (25), III 54-66(18-22), IV 56-65(19-22), V 41-47(18-19), VI 56-64(22), VII 16-19 (6-7); III and IV segments with forked sense cones, L of III 26, IV 26-28.

Pronotum L 126-150, W at anterior margin 167-198, W at posterior margin 189-205, posteroangular setae, inner 64-91, outer 63-79; sublateral setae 22-35; posterior margin with 3 pairs of setae, innermost postoromarginal setae 28-38 long and 41-48 away from each other surface completely sculptured with transverse striae. Metascutum with inner pair of setae 41-58 long, outer pair of setae 31-47 long; sculpture of longitudinally reticulate lines; companiform sensillae present in posterior part. Fore wings L 924-1134, W at middle 47-52; costa with 30-32 setae; upper vein with 4+3 or 7 basal and 1+1+1 distal setae; lower vein with 15-17 setae; scale with 5+1 setae. Fore femur W 53-63 at middle; hind tibia L 180-224.

Abdominal terga II to VIII medially smooth; II with 3 lateral stout, long marginal setae. Laterotergites without microtichia or accessory setae except a very minute seta borne on II laterotergite area. Abdominal tergum I completely sculptured with transverse lines. Comb on posterior margin of tergum VIII complete with 30-33 fine long microtrichia. Tergum X split longitudinally through most of its length, 56-70 long. Accessory setae absent on sterna; median pair of primary setae on VII sternum ahead of posterior margin. Length of setae on segment IX: S1 72-79; md 53-63 (interval between basea 63-82); S2 101-127; S3 126-130; on X: S1 110-127; S2 104-120. Ovipositor L 280-300. Total length (distended): 1475-1835.

Material examined: **Holotype** ♀, West Bengal: Darjeeling, ex flowers of *Citrus* sp.; 4.iii 1980, leg. Vijay Veer. **Paratypes** 8 ♀♀, West Bengal Darjeeling, ex flowers of unidentified ornamental plant, 7.iii. 1980 leg. Vijay Veer.

The species is named after Dr. P. K. Sen-sarma, Director Biological Research, F. R. I. & Colleges, Dehradun.

Remarks: The species, *Thrips sensarmai* sp. nov. comes close to *Thrips formosanus* Priesner, 1934 and *Thrips tanicus* Bhatti, 1969 in having (i) 7-segmanted antennae (ii) 3 distal setae on infumated fore wings, (iii) inner pair of metanotal setae placed behind anterior margin and (iv) sterna without accessory setae. But *T. sensarmai* sp. nov. differs from *T. formosanus* in having 3 lateral setae on tergum II and shorter interocellar setae than postocular setae No. I. It diffes from *T. tanicus* in having 3 lateral marginal setae on tergum II, interocellar setae inserted outside ocellar triangle just touching the tangent along outer margins of fore and hind ocelli on either side and in longer body size and greater length of body setae.

Acknowledgements: The authors are thankful to Dr. J. S. BHATTI, Hans Raj College, Delhi for confirmation of the identity of the species and to Dr. S. K. KULSHRESTHA, DAV college, Dehradun for encouragement.

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BRIEF COMMUNICATION

RELATIVE TOXICITY OF SOME INSECTICIDES TO BANANA RHIZOME WEEVIL, *COSMOPOLITES SORDIDUS* (GERM.)

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(Received 5 August 1984)

Based on the LC_{50} values assessed in the laboratory studies, phorate was found to be the most toxic insecticide to banana rhizome weevil followed by carbofuran, aldicarb, carbaryl and hexachlorocyclohexane in the descending order.

(Key words: banana rhizome weevil, LC_{50}, relative toxicity, *Cosmopolites sordidus)*

Banana rhizome weevil *Cosmopolites sordius* (Germ.) (Coleoptera : Curculionidae) is ranked the most serious pest of banana in India (SINGH, 1970). Plants when attacked in the early stages result in the cessation of growth and gradual death while reduction in vigour and yield are the results when attacked in the grown-up stages of the crop. In acute cases the plants may lodge. The insecticides found effective for the control of the pest include carbofuran (NAIR *et al*, 1977) and disulfoton, BHC, sevin, phorate and carbofuran (NAIR, 1979).

But previous information based on objective evaluation on the relative toxicity of insecticides which can be used in soils to the adults *C. sordidus* is lacking. So in the present studies the toxicity of some insecticides to the adults has been assessed in the laboratory.

The insects were reared in the rhizomes of banana and 10-12 days old adults were used for the studies. To estimate the toxicity of the insecticide, 20 g of dry soil was taken in a petridish of 10 cm dia. and solution of technical grade of the insecticide in acetone was mixed with the soil using 20 ml of the solution per petridish. Concentration of the insecticide in the soil was fixed by changing its concentration in the solution. Four graded concentrations were used for treating the insect. After thorough mixing, the soil was exposed under a fan. The insecticide-impregnated soil was moistened with water for giving sufficient moisture for the survival of the beetle. Fifteen adult beetles were introduced into each petridish containing the treated soil. Each treatment was replicated four times. The petridishes were kept closed. Observations on mortality of adults were taken 72 hours after the release of the beetles to the treated soil The data were subjected to probit analysis and LC_{50} values determined.

Results present (Table 1) showed that based on LC_{50} values phorate (1.90) was the most highly toxic insecticide to the beetle followed in the descending order by carbofuran (6.45), aldicarb (7.24), BHC (120.2) and carbaryl (144.5)

TABLE 1. Relative toxicity of different insecticides to adults of *C. sordidus*.

Insecticide	Heterogeneity	Regression equation	LC_{50} (ppm)	Fiducial limit	Relative toxicity
BHC	$\chi^2_{(2)} = 3.16$	$y = 3.43x - 7.024$	120.2	148.755 – 91.645	1.0
Carbaryl	$\chi^2_{(2)} = 0.46$	$y = 4.9x - 5.82$	144.5	194.088 – 94.912	0.832
Carbofuran	$\chi^2_{(2)} = 5.82$	$y = 3.27x + 2.3766$	6.45	7.182 – 5.718	18.64
Phorate	$\chi^2_{(2)} = 7.81$	$y = 3.4x + 0.7938$	1.90	2.549 – 1.251	63.26
Aldicarb	$\chi^2_{(2)} = 5.47$	$y = 3.7x + 1.905$	7.24	8.807 – 5.681	16.60

Comparing the toxicity of the various insecticides with BHC taken as the unit, the other insecticides phorate, carbofuran, aldicarb and carbaryl were found to be 63.26, 18 64, 16.6 and 0.83 times as toxic as BHC respectively. But studies conducted under field conditions by NAIR (1979) showed that the population of grubs and pupae in the rhizomes treated with insecticides applied on the slurry was low in disulfoton (0.4) followed by BHC (1 1), carbofuran (1.8), carbaryl (2.1) and phorate (3.1).

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